Δ
153.68
A236f
c.2

UNIVERSITY
OF FLORIDA
LIBRARIES

1853

COLLEGE LIBRARY

Digitized by the Internet Archive
in 2010 with funding from
Lyrasis Members and Sloan Foundation

http://www.archive.org/details/factoranalysisof00adki

FACTOR ANALYSIS
OF REASONING TESTS

By

DOROTHY C. (ADKINS) Wood
and
SAMUEL B. LYERLY

with the assistance of
GOLDIE DEMB AND DANIEL W. CAMPBELL

Chapel Hill
THE UNIVERSITY OF NORTH CAROLINA PRESS
1952

University of Florida
1853

TABLE OF CONTENTS

Preface iii-iv

Introduction 1-5

Part I, Preliminary Factor Analysis of 38 Air Force Tests 6-17

Part II, Factor Analysis of a 66-Variable Battery 18-90

  Ch. A. Description of the Variables 18-57

  Ch. B. Collection of the Data 58-62

  Ch. C. Analysis of the Data 63-90

Part III, Summary and Conclusions 91-97

Appendix I, Tables for the Preliminary Study 98-106

Appendix II, Tables for the Major Study 107-122

PREFACE

The work reported herein was carried out under a contract (#WSW2492) with the Personnel Research Section, Office of the Adjutant General, Department of the Army.* We wish to acknowledge first of all the helpful cooperation of members of the staff of the Personnel Research Section: Dr. Donald E. Baier, Chief; Dr. Erwin Taylor, Assistant Chief; the late Dr. Donald Sisson, Assistant Chief; the late Dr. Charles I. Mosier, Assistant Chief; Dr. Julius E. Uhlaner, Chief, Recruitment, Selection, and Classification Research Unit; and Mr. Edmund F. Fuchs, Research Psychologist.

We also wish to acknowledge the assistance of a number of other persons. Chief among these is Professor L. L. Thurstone, who consulted with us on the tests to be included for identifying reference factors, very generously placed at our disposal a large number of tests, and advised us on many aspects of the study. A group of psychologists from the Educational Testing Service and/or Princeton University consulted with us on test ideas and hypotheses worth exploring: Dr. Harold Gulliksen, Dr. Ledyard Tucker, Dr. William B. Schrader, Dr. William Mollenkopf, Dr. Joseph K. Adams, Dr. William Stephenson, Dr. Carroll Pratt, Dr. Norman Frederiksen, and Dr. John French. Dr. Gulliksen and Dr. Tucker have also consulted with us on other aspects of the study.

Special thanks are due Dr. John French for an additional reason. He has very kindly made available to us a prepublication draft of his work on The Factorial Composition of Aptitude and Achievement Tests (soon to be published as Psychometric Monograph No. 5), which has been invaluable in facilitating referring to previous factorial studies.

Dr. J. P. Guilford, who is doing a related study on reasoning under a contract with the Department of the Navy, has been very cooperative in exchanging ideas with us. Other persons who have served in a consulting capacity are Dr. John F. Dashiell, Dr. William Daniel, Dr. H. G. McCurdy, Dr. Irvin S. Wolf, all of the Department of Psychology of the University of North Carolina, and Dr. L. O. Kattsoff of the Department of Philosophy.

Many organizations and individuals were helpful in granting us permission to use test materials. As mentioned before, Professor L. L. Thurstone made a number of tests available. The Army Air Force was especially helpful in providing materials for our use. Some, of course, were made available by the Office of the Adjutant General, Department of the Army, which sponsored the study.

The Rev. W. A. Botzum, who was engaged in a factorial study of reasoning and closure factors, also permitted us to use or adapt some of his tests. The source of each test that we used is stated in the test descriptions given in Part II, Chapter A, of this report. Here will be mentioned that special permission was granted for the use or adaptation of material for one or more tests by the following additional firms or individuals: The Educational Testing Service, the United States Employment Service, the British Air Ministry, the Institute of Living, Press Features, Inc., Teachers

---

*The opinions expressed are those of the authors and do not necessarily reflect official policy of the Department of Defense.

College Bureau of Publications, Science Research Associates, the California Test Bureau, the Psychological Corporation, and the World Book Co. In addition, a subtest of the Blakey-Brown Non-Verbal Test, the Chicago Reading Test (constructed by Max D. Engelhart and Thelma Gwinn Thurstone), and two of Calvin W. Taylor's tests were adapted to our needs.

Much of the work of adapting and editing tests and preparing them for the printer fell upon our two chief assistants in the project, Miss Goldie Demb and Mr. Daniel Campbell, who were graduate students at the University of North Carolina. They also did the major share of the work of constructing new tests that were included and participated in many phases of the investigation--the initial exploration of test ideas and hypotheses, reaching decisions on the tests to be used, conducting pretrials, planning for the scoring, and performing the factor analysis itself. Mr. John Hanson also constructed one test for this project.

Other members of the project staff have been Mr. Albert Branca, who administered all the tests; Mr. Leonard Matin, who has worked on assembling materials for the final report and has assisted in some of the computational work; Mrs. G. F. Kuder, who supervised the work of scoring the tests, getting the frequency distributions, and coding the scores; Mrs. Frank Giraffe and Mr. Clyde Young, who, together with Miss Demb, Mr. Campbell, Mrs. Ruth Maxwell, and the authors, did the computational work involved in the centroid analysis and rotation of axes; Mr. W. J. Crank, who did much of the drafting and art work; and Miss Lucy B. Adams, Mrs. Ruth Maxwell, and Mrs. Josephine Cameron, who have been responsible for typing both the test copy and the manuscripts required for this study.

Mention should also be made of the excellent service of the computational staff of the Institute of Statistics of the University of North Carolina, which did the International Business Machines work involved in obtaining the squares of the product-moment correlation coefficients among our variables. Mr. Stuart Hunter planned and supervised this work.

Finally, our great appreciation is also due the many persons at Fort Jackson, South Carolina, who cooperated with us to make the study possible. Among these persons, special mention should be made of General George H. Decker, the Commanding Officer; Major George Reed, Assistant Adjutant General; Captain Everett E. Floyd, Commanding Officer, Testing Station; and the 226 men from Companies E, F, and G of the Second Infantry Regiment who devoted 15 hours to taking the tests that were to be analyzed. Special thanks are also due the following men who served as proctors: Cpl. Harold W. Perry, Cpl. William J. Sandeford, Cpl. Jerry E. Brown, Cpl. James E. Barron, Cpl. Dale E. Collyer, Pfc. James O. Tucker, Pfc. William E. Ryan, Pfc. Howard L. Miller, Pfc. Reginald Maxwell, Pvt. Charles E. Hendrix, Pvt. William C. Robinson, and Pvt. Glenn E. Casey.

INTRODUCTION

Among the many varieties of human abilities, perhaps greatest admiration is reserved for thinking--especially the kind of thinking that is regarded as "reasoning." Even the lay person stands in awe of it. Philosophers and psychologists have also regarded reasoning ability as warranting much attention. From a practical standpoint, if some jobs require a greater degree of reasoning than do others, then a better understanding of its nature and improvements in measuring it should be reflected in greater efficiency in the selection and classification of workers.

Many kinds of tests have been rather loosely associated with reasoning or referred to as reasoning tests. Many tests that masquerade under this title, however, almost certainly are not really measuring the same basic ability but rather several abilities, some of which may be inter-related. This suggests that the domain of reasoning can be clarified by an attempt to identify systematically the abilities that account for individual differences in the various tests that have been called "reasoning."

Some very useful findings have sprung from the application of the techniques of factor analysis to batteries of different kinds of mental tests. From these studies, psychologists have learned a great deal about the organization and interplay of abilities. Certain abilities have been revealed with sufficient consistency from one group of tests and one group of subjects to others that many psychologists have come to regard them as pretty well established as "fundamental" or "primary." Among these are verbal comprehension, or the ability to understand verbal symbols and their relationships; verbal fluency, or the ability to make verbal responses with ease; ideational fluency, or facility in producing ideas; and numerical skill, or the ability to deal rapidly with simple numerical operations. Clearly distinct from these are factors related to perception, space, and memory. Some of the latter are being broken down into two or more factors as studies are made on a variety of tests designed to evaluate different hypotheses, but their essential identity is fairly well understood.

In the field of reasoning, however, more conflicting results and interpretations are encountered. Thus one study will be reported as yielding a factor identified as "general reasoning"; another using some of the same tests plus additional ones will produce "induction"; another will result in not just one but apparently three or four factors possibly associated with reasoning, although their nature will not be clear; another will report "deductive reasoning"; another will raise the question of the possible identity of some type of reasoning factor with a flexibility previously thought to be associated mainly with perceptual tests; while still another will show no evidence of a "reasoning" factor at all.

This project was undertaken in an attempt to clarify the underlying nature of the abilities affecting performance in types of tests that have been identified previously or suggested as measures of reasoning. The project staff devoted a considerable amount of time during the early months of the study to readings and discussions on reasoning, including both the psychological and the philosophical literature. We were impressed

with the great variety of definitions, points of view, and criteria adopted or entertained by the various authors. Reasoning, like many other psychological phenomena, may be approached at different levels and with different degrees of analytic or descriptive completeness, depending upon the purpose and the theoretical orientation of the writer.

We did not attempt to frame a definition of reasoning, but we did gather descriptions of reasoning behavior from various sources and descriptions of situations in which behavior considered to be reasoning is said to occur. We then attempted to select or construct one or more tests each of which required one or more of the kinds of behavior that had been encountered.

The list of situations or problems is given below. They are not intended to be exhaustive, nor are the situations mutually exclusive. Neither are they systematically organized or stated in terms of any set of psychological theories.

Situations giving rise to reasoning behavior:

1. Problems which require that the individual discover a rule or principle expressing relationships among elements and then extend or apply the rule or principle.

2. Problems which may be solved more easily by "insightful" or "short-cut" methods than by more obvious direct attack.

3. Problems which require that the individual transform or transfer conceptual or ideational material into some other form or medium.

4. Problems which require the individual to advance a plausible and "good" hypothesis to explain or account for a phenomenon.

5. Problems which require the individual to draw the appropriate conclusions or inferences from information given -- the so-called "deductive" process.

6. Problems which require that the individual manipulate symbols and abstractions.

7. Problems which require the individual to perform trial-and-error behavior vicariously and select a "best" response after a series of such "trials."

8. Problems which require the individual to combine several principles, experiences, or concepts into new, different, or unusual relationships.

9. Problems which require that the individual detect "fallacies" or improper conclusions or deductions.

It is obvious that not all of the above items are equally amenable to study by means of written tests. While reasonably reliable tests have been constructed in some of these areas, others, No. 8, for example, do not lend themselves to measurement by ordinary group testing procedures. More elaborate individual testing instruments, or perhaps controlled observational studies somewhat on the order of those in the assessment program of the Office of Strategic Services, would be required for a thorough analysis of such behavior. While the limitation to paper-and-pencil tests is a serious one as far as the study of reasoning as a psychological phenomenon is concerned, it is a restriction consistent with the major purpose of the study, since paper-and-pencil tests will probably continue for some time to be among the important tools for the assessment of human aptitudes.

Although there have been several studies in which reasoning tests of various sorts have been analyzed, the interpretations of the results have been far from consistent. One reason why some of the previous studies in this field have been inconclusive is that not enough tests nor a sufficient variety of tests within the realm of reasoning have been given to the same sample of subjects. The general plan of this study, therefore, was to administer as large an assortment of such tests as possible to the same group of subjects and to analyze the results factorially.

Another reason why the meaning of certain factors found in earlier studies is vague is that the tests used may have been unnecessarily complex. If several very complex tests are associated with a single factor, it becomes very difficult to extract the characteristics that they have in common and thus often impossible to understand the intrinsic nature of the ability. For this reason, we planned to use many tests that were likely to be relatively simple in factorial composition. It is probably not possible to construct a test that measures "reasoning" and nothing else, because the medium--words, numbers, figures, and so on--in which the reasoning takes place almost surely will intrude itself. Nonetheless, to aim at tests as factorially pure as possible appeared to be worth while. There was, however, a danger of losing the very essence of reasoning by restricting the battery to problems so simple that they conceivably might be soluble by means of abilities other than reasoning. We therefore purposely included some tests that we strongly suspected would depend on several factors.

A third consideration that influenced the planning of this study was that some of the difficulties in interpretation of the findings of earlier studies have stemmed from a failure to include reference tests for well-established factors with which reasoning is likely to become confused. If a test battery does not contain several tests to clearly identify the verbal comprehension factor, for example, it is more difficult to establish the nature of factors with which other tests presented verbally are saturated. Thus what appears to be possibly a reasoning

factor may be the verbal comprehension factor or an unresolved complex of reasoning and verbal comprehension. In order to avoid this problem, our original plan was modified to include in addition two reference tests for each of nine previously reported "non-reasoning" factors.

Still another question that has arisen from previous studies relates to the generality of reasoning abilities. If in one study a factor heavily loaded on a test of number series and perhaps other tests dealing with numbers shows up, is it the same factor that another investigator has reported to be loaded on a letter series test and additional tests involving letter groups or sequences? Or can it be identified with a factor on which figure series has been reported to be loaded? The question is, then, whether or not the nature of the factor identified in one study transcends the medium in which the test is presented. In order to throw light on this question, it is necessary to include in a single study several tests that are alike in the type or form of mental operation required but that differ in the medium of presentation. Application of this line of argument to several types of tests meant that we soon had to modify our original idea of using only 25 to 30 reasoning tests.

A somewhat related objective that also increased the number of variables was to incorporate into the same battery tests that seem to involve some operations that are alike as well as some that differ. Thus, for example, we planned to include some tests that require the completion of series of various sorts together with different kinds of analogies tests. A test battery containing both series and analogies tests should add to our understanding of the relation between factors previously associated primarily with one or the other. It might be that one factor permeates both while each is affected, in addition, by a factor peculiar to it.

Thus because several considerations argued for the analysis of a single battery of a large number of tests taken by the same subjects, our original plan of analyzing a battery of only 25-odd tests and then performing a check analysis of the most promising tests upon a second sample was abandoned in favor of a single exploratory study of roughly two and a half times as many tests as had initially been contemplated.

Soon after the initiation of the project, it became clear that decisions on what tests to include would have a crucial bearing on the value of the results. It was early agreed, therefore, to devote a sizeable portion of the available resources to deciding upon, selecting or constructing, and editing the tests to be used. As a first step, we systematically reviewed the literature for test ideas. This survey gave particular attention, of course, to factor analysis studies and included consideration of available tests. We also solicited test ideas and hypotheses as to the nature of reasoning from general psychologists, philosophers, psychologists specializing in the field of tests, and, in particular, those experienced in factor analysis. From these approaches, we assembled a number of specific ideas about tests that ought to be

included and a variety of hypotheses as to the nature of reasoning. No attempt will be made herein to recount the many factors governing our final decisions to accept or reject each specific test idea. Nor shall we at this point outline the variety of hypotheses that confronted us. These will be treated in sufficient detail, we trust, in the interpretation of our results.

In view of the large number of tests to be included in our major study, we restricted it to paper-and-pencil group tests. Although we would have liked to explore some hypotheses that could not be investigated by such tests, practical considerations led us to this decision.

The entire set of tests was developed for hand-scoring, the answers being recorded directly on the test booklets. It was feared that the necessity of coding and transferring answers to a separate answer sheet might introduce an undesirable clerical complexity into the test tasks and distort their factorial composition. In addition, some of the tests, such as those of verbal fluency, are of the completion type and are not adaptable to machine-scoring.

The value of machine-scoring for tests to be administered on a large scale was recognized. It was decided, however, that if any promising leads for tests of reasoning ability grew out of the study the possibility of adapting them for machine-scoring could be explored later.

One of the sources of test ideas and hypotheses to which we early turned was the series of Aviation Psychology Program Research Reports published by the Army Air Force, and especially Report No. 5, Printed Classification Tests, edited by J. P. Guilford. Here is found an impressive array of data resulting from a number of factor analysis studies in the general area of reasoning. In particular, we studied the results of batteries referred to as reasoning, integration, judgment, and planning and foresight. Some of these batteries contained only a small number of tests, so that not only was the interpretation of some of the factors at best cloudy but also the relations among the factors were impossible to establish. Since we could not include in our study every test tentatively identified with some factor in the realm of reasoning, we decided to apply factor analysis to the intercorrelations among the most-promising tests from the Air Force batteries. Fortunately for our purposes, these intercorrelations were available in the Air Force report. Our plan, then, was to base our selection of Air Force tests upon a preliminary factor analysis of 38 variables, including some reference tests. This study is reported in detail in Part I, Preliminary Factor Analysis of 38 Air Force Tests.

Part II, which is subdivided into three chapters, presents a detailed treatment of our major analysis of 66 variables, including those selected on the basis of the preliminary analysis reported in Part I.

Part III is devoted to a summary and conclusions for the entire project. Appendix I contains the tables referred to in Part I, Appendix II those referred to in Part II.

PART I

PRELIMINARY FACTOR ANALYSIS OF 38 AIR FORCE TESTS

One of the most promising sources of information about factorial composition of tests in the domain of reasoning is the Army Air Forces Aviation Psychology Program, Report No. 5, Printed Classification Tests, edited by J. P. Guilford. Here will be found 14 factorial analyses of tests, some of which appear possibly to partake of the nature of reasoning. These are identified as Nonverbal Reasoning, pp. 113-122*; Planning and Foresight I and II, pp. 180-191; Integration, pp. 215-225; Memory I and II, pp. 261-268; Mechanical, pp. 333-339; Perceptual I and II, pp. 408-418; Carefulness, pp. 686-695; and four analyses of the Classification Battery: December 1942, July 1943, November 1943, and September 1944, pp. 798-819.

Each of these studies involved a different battery of tests, ranging in number from 14 to 32, although there was some overlapping. Two of the tests in which we were interested, Arithmetic Reasoning and Complex Coordination, were common to all. A brief resumé of the factors that incited our curiosity will be accompanied by a table (Table 1**) giving the (Air Force's) rotated loadings (for each of the studies for each of these factors) on the 20 tests that had a loading as high as .25 on any one of the factors. Then a reanalysis of a battery composed of these tests plus 18 additional ones that we felt would be useful for reference purposes will be presented in detail. This analysis was made to assist us in the selection of tests to be included in a larger battery.

The first study, referred to as Nonverbal Reasoning, resulted in four factors allied to the realm of reasoning. These were:

> Reasoning I (R_I). "Identified as the general-reasoning factor, usually defined by Mathematics B (a typical arithmetic reasoning test). All the tests, with the exception of Figure Classification, that were considered to be promising nonverbal reasoning tests contain this factor...." (p. 118)

> Reasoning II (R_{II}). "This new factor defied precise definition. No test has a very high saturation in the factor, and all the tests on it are complex. Two tentative definitions of this factor have been proposed. The first is that it is a visual memory factor..... The second hypothesis is that it is another reasoning factor although it is not precisely definable yet." (pp. 119-120)

> Reasoning III (R_{III}). "All the experimental reasoning tests except Number Series Completion appear projected on this factor, albeit with moderate loadings. There is thus strong indication

---

*Unless otherwise indicated, page references in Part I are to the A.A.F. Report No. 5.

**All tables referred to in Part I are contained in Appendix I.

> of the existence of a new reasoning factor. The moderate loadings in this factor, however, make it difficult to formulate a definition." (p. 120) It is "strongest in tests that seem to require sequential reasoning and in which frequently one can arrive at the correct answer by elimination of wrong answers." (p. 838)
>
> Integration III (I_{III}). "This factor seems to be integration III (see ch. 10), and perhaps it is clearly described by the phrase 'taking into account.' In all the tests on this factor, the examinee is required to select one of many courses of action. His selection of the correct one depends upon his ability to take into account all the aspects of the given situation." (p. 120)

In two analyses of so-called Planning and Foresight batteries (I and II), the pertinent factors identified were:

> Reasoning I (R_I). "...called general because it is common to more tests than either of two other factors that are peculiar to reasoning tests ... most of the planning tests have some small but probably significant loadings in this factor." (p. 187)
>
> Judgment (J). "With the four judgment tests all having equivalent loadings on this factor, although no test is in both batteries, the identify of the factors....could hardly be mistaken. .... The best hypothesis for this factor is judgment--the ability to weigh solutions and select the wisest and best ones. This factor was also found in the analysis of judgment and reasoning tests." (p. 189)
>
> Planning (Pl). "This factor cannot be satisfactorily interpreted at present. One hypothesis might be that it represents an ideational fluency; ... Another hypothesis might be that this is some form of visualization different from the manipulation type... .. Only further data will more clearly define this factor." (p. 189)
>
> Integration III (I_{III}). "This seems to be identifiable with the factor called integration III, to be described in chapter 10. It is curious that the only factor that has so many of the planning tests in common, and only planning tests to any significant degree, should not be called planning.... The term 'integration III' merely arises from the fact that it was discovered in the integration battery." (p. 190)

The Integration battery resulted in four factors in which we were interested:

> Integration I (I_I). "Here is decidedly a new factor, characteristic of the integration tests. None of the three is a pure measure of it. The factor...may be called integration I until more is known regarding it. The chief thing that these tests

> have in common is the requirement for the examinee to memorize and to retain a number of rules.... From this consideration the variable might be defined as a memory factor." (p. 222)
>
> Integration II (I_{II}). "The distinguishing feature of the leading test.....is apparently an ability to adapt quickly to new instructions and to carry them out successfully. Almost every item introduces new variations or modifications of general instructions given at the beginning..... It would be highly desirable.... to correlate these tests with memory tests in order to determine the possible identify of this factor with some memory factor. Until further information is forthcoming, it is best to name this factor integration II." (p. 222)
>
> Reasoning I (R_I). "This is the usual (emphasis ours) general-reasoning factor.... This one...shows up strongly in several of the integration tests." (p. 223)
>
> Integration III (I_{III}). "This factor list includes a combination of integration and reasoning tests. It seems to be identical with a factor isolated in two other analyses (Non-verbal Reasoning, Foresight and Planning II).... The tests, with two possible exceptions, ...seem to have in common the necessity for keeping in mind a number of detailed considerations provided either from the instructions or from the objects used in the items.... One hypothesis would be that it is a span of apprehension or scope of apprehension. Another might be that it involves mastery of details. A third hypothesis....is that the factor is ideational fluency.... Until further definitive evidence is available, it is best to name the factor integration III." (p. 224)

The two Memory studies, the Mechanical battery, and the two Perceptual studies each revealed apparently the same factor as that previously referred to as Reasoning I. It is stated that

> This is most probably the general-reasoning factor always found in Arithmetic Reasoning and Reading Comprehension.* (p. 266) .... The heterogeneous list of tests is not unusual for this factor. General reasoning--most constant

---

*The loadings of this factor on Reading Comprehension for the Memory studies were .39 and .40. Yet in a later discussion of the analysis of the Carefulness battery, a loading of .60 on Reading Comprehension for a factor with a loading of .63 on Arithmetic Reasoning was regarded as markedly atypical. It was noted that Reading Comprehension has a much smaller average loading on the factor (.19) than in that analysis, and the factor is in that study identified only as a rough combination of general-reasoning and verbal factors (p. 691). Regarding this reference to the average loading of .19 on the general reasoning factor,

> component of arithmetic reasoning tests--shows up in many places. The ability is apparently a kind of "all-purpose" or "trouble-shooting" trait, which is called into the picture when more immediate comprehension is lacking. (p. 339) .... It was not clear at the time the factor was first isolated whether or not the modifying term "inductive" should be used in connection with its description. Many tests, clearly inductive in character, do have high loadings on the factor. It is also probable that at least two of these reasoning factors have been isolated. (p. 416)

In the study called Carefulness, a factor with loadings of .63 on Arithmetic Reasoning, .60 on Reading Comprehension, and .34 on Mechanical Principles was found. The difficulty of reconciling this variable with findings from other analyses was recognized, especially in view of the atypically high loading on Reading Comprehension. "The evidence cited seems to indicate that the factor is a rough combination of the general-reasoning and verbal factors which are identified separately in other analyses."* (p. 691)

There were four analyses of the AAF Classification Battery, identified by date, which were based on larger populations (N's from 1900 to 8158) than the other studies. In three of these studies (excluding the November 1943 one) a factor was identified as corresponding to that called general reasoning (R_I) in earlier studies. The loadings on this factor for Mathematics B, an arithmetic reasoning test, were .36, .48, and .47 while the loadings for Reading Comprehension were .27, .26, and .28, respectively. The report reads: "This combination of tests and these loadings coupled with other experience forces us to accept it as the general-reasoning factor (R_I).... The lower loading of R_I for Mathematics B in the December 1942 analysis is probably due to the presence of the Numerical Approximation test...." (p. 818) In the November 1943 study, "it was impossible to separate the numerical factor from general reasoning in spite of considerable effort to do so." (p. 800) This battery lacked several useful reference tests, including Numerical Operations, which probably accounts for the difficulty. (p. 800) One factor, unnamed, had a loading of .58 on Mathematics B (arithmetic reasoning), .56 on Mathematics A (arithmetic computation or numerical operations), .46 on Decoding, .30 on Instrument Comprehension, and, curiously enough, .48 on Reading Comprehension. We have labelled it R_I-N to indicate that it is a complex that probably includes these factors.

Table I contains a section for each of the afore-mentioned studies and a column for each of the factors discussed above that was identified in the studies. The entries in that table are orthogonal factor loadings for the tests listed at the left.

(Continuation of previous footnote.) however, it should be pointed out that inspection of the table of weighted average factor loadings in Appendix B of the report, which is discussed on pp. 821-2, clearly indicates that in this particular instance the so-called average is the "average" of only one observation, the loading for the Integration study. Reference to such an average may be misleading.

*Refer to previous footnote.

In attempting to decide which of the tests in Table 1 might best be included in our projected 66-variable study, we concluded that there probably was more identity among the various reasoning, judgment, planning, and integration factors than could be readily apparent from a series of studies based for the most part on different tests. Some intercorrelation data on these tests, not entirely satisfactory but reasonably adequate to provide better answers than were otherwise at hand, are available in Appendix C to the Aviation Psychology Research Report No. 5. This appendix gives a matrix of the intercorrelations of 65 tests, including the 20 listed in our Table 1. It also includes 18 additional tests that should assist in differentiating any new and relatively unclear factors from better-known ones and which we hence used in our study.

The samples were not the same for all of the correlation coefficients. A group of 8158 unclassified aviation students at Sheppard Field, Texas, were given the 21 tests of the September 1944 Classification Battery. In a planned program of overlapping samples and overlapping batteries, sub-samples of approximately 400 to 440 students took various groups of experimental tests in addition to the Classification Battery. We have no information concerning the comparability of these sub-samples. Our purpose, however, was not to reach final conclusions about the nature of the factors but only to secure evidence for including or excluding particular tests from a large battery that was to be administered to a single sample and factor-analyzed. To this end, we reconstructed from the Air Force's data a matrix of the 38 tests (20 perhaps allied to reasoning and 18 to identify reference factors) that we wished to analyze as a unit. This matrix is presented in Table 2.

No attempt will be made here to describe the tests, since all except Block Counting are described in Report No. 5. It may be mentioned, however, that 18 of these tests or very similar tests were selected for inclusion in the major study reported in Part II. These tests, which are indicated in the list below by an asterisk, are described and illustrated in Chapter A of Part II, where all of the tests in our major study are treated in detail.

The list below shows the set of tests that we analyzed. In this list and in all tables for this study, the 38 tests are presented in the order in which they appear in the 65-test matrix in Appendix C of Report No. 5.

1. Map Memory, CI505BX1
*2. Figure Analogies, CI212AX1
*3. Spatial Visualization II, CI203A (See our Painted Blocks)
4. Planning Air Maneuvers, CI408AX2
*5. Vocabulary, CI604BX1
6. Estimation of Length, CP631B
7. Speed of Identification, CP610C

---

*The asterisks indicate tests which are identical or very similar to tests included in the major study.

8. Memory for Plane Silhouettes, CI503AX1
9. Directional Orientation, CP515F
10. Visualization of Maneuvers, CI657CX2
*11. Planning a Circuit, QP901A-I
12. Visual Memory, CI514A
*13. Figure Classification, CI213AX1 (See our Figure Classification I)
*14. Spatial Visualization I, CI204AX1 (See our Paper Folding)
15. Objectivity of Perception, CP806CX2
*16. Decoding, CI214AX2
17. Route Planning, CI411AX1
18. Flight Formation, CI654AX5
19. Pattern Assembly, CP804A
*20. Block Counting, CP512B-4
21. Plane Name Memory, CI503AX2
22. Planning a Course, CI406AX3
23. Competitive Planning, CI409AX2
*24. Camouflaged Outlines, CP821A
*25. Spatial Reasoning, CI211BX2 (See our Circles test, which is patterned after the Thurstone Marks test).
*26. AAF Word Knowledge, CI604C
27. Dial and Table Reading, CP621-622A
28. Spatial Orientation I, CP501B
29. Spatial Orientation II, CP503B
*30. Reading Comprehension, CI614H
31. Instrument Comprehension II, CI616C
*32. Mechanical Principles, CI903B
*33. Numerical Operations I, CI701B
*34. Numerical Operations II, CI701B
*35. Mechanical Information, CI905B
*36. Practical Judgment, CI301C
*37. Arithmetic Reasoning, CI206C
38. Complex Coordination, CM701A

The provisions made for several of the reference factors deserve some explanation. Since so many "reasoning" tests (both the "verbal" and "nonverbal" varieties) involve the use of language either in the test materials or in the instructions, and since the "General Reasoning" factor (R_I) in the Air Force's reports has been found prominently in several tests with high or moderate verbal content (Arithmetic Reasoning, Reading Comprehension, etc.), it was considered important to be able to locate an unequivocal verbal factor. For this reason, the Vocabulary test and the AAF Word Knowledge test, which are not weighted with quantitative or mechanical content, were selected to identify the verbal factor.

The number factor was another reference factor which seems to be closely allied to many of the "nonverbal" reasoning tests. The identification of this factor is especially important since the Arithmetic Reasoning test has been reported in every analysis as the strongest test in R_I, the general reasoning factor. Several of the Air Force batteries have relied upon Arithmetic Reasoning itself as one of the identifying tests for the number factor in addition to one other

arithmetic test (e.g., the Nonverbal Reasoning Analysis and the Foresight and Planning Analysis). The lack of a clearly independent group of numerical tests may account for some of the puzzling loadings of the arithmetic reasoning test, e.g., its higher N loadings when it is used to define the N factor (.65 in the Foresight and Planning Analysis) than when the N factor is independently defined by other tests (.38 in the Integration Analysis). For our analysis, the two Numerical Operations tests, which have been shown to be almost "pure" numerical tests in various analyses, were chosen to provide a clear and dependable reference vector for N.

Four memory tests (Map Memory, Memory for Plane Silhouettes, Plane Name Memory, and Visual Memory) were chosen for inclusion in view of the hypotheses tentatively advanced by the authors of the AAF report that Reasoning II and Integration II were memory factors. It was hoped that these four tests would provide an opportunity to test these hypotheses.

Other tests were selected because of their known loadings in spatial and perceptual factors (Speed of Identification, Spatial Orientation, Complex Coordination, Instrument Comprehension, etc.). Mechanical Information and Mechanical Principles were included because of the possibility that the mechanical experience factor found in a number of AAF analyses might be involved in some of the reasoning tests. The AAF's Nonverbal Reasoning Analysis did not provide for this factor, since only one mechanical test, Mechanical Principles, was included; and no mechanical experience factor was found.

Thurstone's centroid method of factor analysis was used in our study. Table 3 presents the centroid factor loadings for the 10 factors that were extracted. Table 4 gives the distribution of residuals after the extraction of the tenth factor. It will be noted that only three of the 703 residuals exceed .10 in absolute magnitude. The mean of the absolute values of the residuals is .035, and the standard deviation is .033.

The centroid vectors were rotated to an oblique simple structure. Table 5 presents the oblique factor matrix, Table 6 the transformation matrix relating the centroid vectors to the rotated vectors, and Table 7 the cosines of the angular separations of the reference vectors.

In comparisons between the factor loadings presented here with those for the same tests in the Air Force reports, it should be noted that projections on oblique reference vectors are likely to be lower than projections on orthogonal reference vectors, particularly for tests which are factorially complex.

The rotated loadings for each of the factors will now be presented, together with a brief interpretation of each factor. For each factor, only the tests for which the rotated loadings are equal to at least .30 are included.

Factor A--Space

Test No.	Test Name	Loading
8	Memory for Plane Silhouettes	.57
10	Visualization of Maneuvers	.44
31	Instrument Comprehension	.42
9	Directional Orientation	.39
14	Spatial Visualization I	.37
11	Planning a Circuit	.33
29	Spatial Orientation II	.33
28	Spatial Orientation I	.31
15	Objectivity of Perception	.31
38	Complex Coordination	.30

This factor we believe to be the same as one of Thurstone's space factors. With the possible exception of test 15, Objectivity of Perception, the tests in the foregoing list require a type of space ability that depends on correct perception of objects after fairly simple movement, such as rotation in two-dimensional space. This factor may be allied to the space factor that Thurstone has identified by his Cards and Figures tests (which involve correct perception of rotations in two dimensions). His recent interpretations of this factor emphasize the ability to visualize a rigid configuration when it is moved into different positions.*

Factor B--Verbal

Test No.	Test Name	Loading
26	AAF Word Knowledge	.79
5	Vocabulary	.68
30	Reading Comprehension	.42
18	Flight Formation	.30

This is clearly the familiar Verbal factor, typically defined by vocabulary and reading comprehension tests. It is interesting that none of the so-called reasoning tests have high loadings on this factor. The explanation for the loading of .30 for Flight Formation probably lies in the verbal complexity of the directions. This is its highest loading in this analysis.

Factor C--Number

Test No.	Test Name	Loading
34	Numerical Operations II	.61
33	Numerical Operations I	.58
27	Dial and Table Reading	.40
37	Arithmetic Reasoning	.35

---

*Thurstone, L. L. Mechanical aptitude III: Analysis of group tests. The Psychometric Laboratory, The University of Chicago. Report No. 55, May 1949.

Evidently this is the common Number factor. Of the tests in the general area of reasoning, only Arithmetic Reasoning has a loading as high as .30 on the Number factor.

Factor D--Visualization

Test No.	Test Name	Loading
32	Mechanical Principles	.56
35	Mechanical Information	.51
3	Spatial Visualization II	.37
20	Block Counting	.37
14	Spatial Visualization I	.31
23	Competitive Planning	.31
31	Instrument Comprehension	.31

This factor, with high loadings on both Mechanical Principles and Mechanical Information, and somewhat lower loadings on the other tests listed, we have termed Visualization. It may correspond to a second space factor that Thurstone reports as identified by a Mechanical Movements test (corresponding to the Mechanical Principles Test), a Mechanical Comprehension test, a Surface Development test, and a Paper Puzzles test (similar to a paper form board test). His interpretation is that it is "the ability to visualize a configuration in which there is movement among the parts of the configuration.*

In a factor analysis of mechanical tests, the Air Force report identified a factor described as follows:

> This is the visualization factor, which also appeared in several other analyses. It seems to be a very common secondary factor in mechanical tests, particularly in those that involve moving mechanisms. This gives one small clue as to the nature of the factor which has been tentatively defined as a manipulatory visualization. Objects are imagined as moving or as having been moved or transformed in tests loaded with this factor. (p. 338)

Elsewhere it is said: "This visualization factor is strongest in tests that present a stimulus either pictorially or verbally, and in which some manipulation or transformation to another visual arrangement is involved." (p. 838)

We included in our major study several mechanical tests and tests of visualization so that the interpretation of this factor and its relation to that identified in Air Force studies as Mechanical Experience could be further studied.

---

*Thurstone, L. L. Mechanical aptitude III: Analysis of group tests. The Psychometric Laboratory, The University of Chicago. Report No. 55, May 1949.

Factor E--Perceptual Speed

Test No.	Test Name	Loading
6	Estimation of Length	.51
19	Pattern Assembly	.48
7	Speed of Identification	.47
28	Spatial Orientation I	.41
24	Camouflaged Outlines	.30

From the loadings for this factor, we interpret it as perceptual speed, commonly referred to as P. All five of the tests listed above appear to require the ability to make simple perceptual discriminations rapidly.

It may be noted that previous Air Force analyses have shown Spatial Orientation II also to be high on this factor, with loadings in the neighborhood of from .45 to .55. The loading of this test on our factor E is only .16. This test has a very low communality in our 38-test battery, its highest loading on any of the 10 factors being only .33 on factor A, which we interpret as being a space factor.

Factor F--Memory

Test No.	Test Name	Loading
1	Map Memory	.45
8	Memory for Plane Silhouettes	.44
21	Plane Name Memory	.42
12	Visual Memory	.35

From the four tests in the foregoing list, factor F can be identified as some type of memory factor involving visualization. These tests appear to depend primarily upon memory for visual configurations rather than upon verbal associations. It does not seem to correspond clearly with any previously identified memory factor. This factor is probably an undifferentiated mixture of several types of psychological processes that may be involved in memory. Hence we have identified it simply as memory.

It may be noted at this point that this analysis provides no evidence for the hypotheses advanced by the Air Force research workers that their Reasoning II and Integration II factors might be some type of memory factor. In the battery that we analyzed, only memory tests have significant projections on Factor F.

Factor G--Nonverbal-Nonnumerical Reasoning (?)

Test No.	Test Name	Loading
2	Figure Analogies	.47
3	Spatial Visualization II	.45
13	Figure Classification	.43
37	Arithmetic Reasoning	.41
14	Spatial Visualization I	.35
30	Reading Comprehension	.31

This factor is clearly nonverbal, the loadings on it for Vocabulary and Word Knowledge being -.06 and .15. It is nonnumerical, the loadings for Numerical Operations I and II being -.04 and .04. As nearly as we can interpret this factor, it is a "nonverbal, nonnumerical reasoning" factor.

We have explored the possibility that this factor corresponds to any of the Air Force's factors R_I, R_{II}, R_{III}, J, Pl., I_I, I_{II}, or I_{III}, with particular attention to the first three. It has some points of resemblance to several of them, particularly R_I and R_{III}, which were identified in the study of Nonverbal Reasoning. We are unable to identify it as clearly corresponding to either of these, although it appears to be more like R_I.

No further interpretation of this factor will be attempted on the basis of this study. Our larger study included 11 tests similar to those with loadings of over .20 on factor G (among them being the six with the highest loadings), with the expectation that it would permit a clearer interpretation of this factor.

Factor H--(Residual)

Test No.	Test Name	Loading
9	Directional Orientation	.37
14	Spatial Visualization I	.30

This, perhaps another spatial factor, is difficult to identify. None of the loadings on it exceed .37, and only two are as high as .30. Its differentiation from factor A, which we interpreted as a space factor, is not clear from this analysis.

Factor J--Visual Pursuit

Test No.	Test Name	Loading
20	Block Counting	.42
11	Planning a Circuit	.34
25	Spatial Reasoning	.34
22	Planning a Course	.31
38	Complex Coordination	.31

Only one test (Block Counting) has a loading higher than .40 on factor J. In all the tests listed, it may be noted that the subject must perform a systematic visual exploration of the stimulus object, whether it be following a pathway through a maze, counting blocks, or "finding the rule" underlying the pattern in each item of the Spatial Reasoning test. The feature that seems to characterize the type of visualization involved and to differentiate it from that involved in ordinary perceptual tasks is its systematic character. It may be the same factor as the Thurstones' factor X_2 in the 60-variable study reported in their Factorial Studies of Intelligence.* This factor had its highest loadings on two maze tests which have much in common with the Air Force's test, Planning a Course. Its third highest loading was in the Pursuit test, which closely resembles the Air Force's Planning a Circuit. The Thurstones attempted no interpretation of the factor beyond calling attention to the visual pursuit element common to the tests involved.

The Air Force's factor that seems to resemble factor J most closely is the one termed S_I in the Air Force reports, the spatial relations factor. The Air Force authors say with respect to this factor, "This...seems to involve relating different stimuli to different responses, either stimuli or responses being arranged in spatial order. It is not clear whether the appreciation of spatial arrangement of stimuli or of responses separately is the key to the factor." (p. 838) Our results, however, do not agree entirely with other Air Force findings for this factor, and we are inclined to favor an interpretation that stresses systematic visual inspection.

For factor K, only one test, Route Planning, had a projection as high as .30. We are therefore attempting no interpretation of it.

The conclusions based on this analysis are given in Part III, "Summary and Conclusions," together with those based on the analysis of our larger battery.

---

*Thurstone, L. L. and Thurstone, Thelma Gwinn. Factorial studies of intelligence. Psychometric Monographs, No. 2, 194 pp.

PART II

FACTOR ANALYSIS OF A 66-VARIABLE BATTERY

Chapter A

Description of the Variables

In this chapter will be given first an alphabetical list of the 66 variables used in our major study, with the code number of each. For the convenience of the reader in locating data or information about each test, the code numbers of the 65 tests have been assigned in accordance with the alphabetical sequence of the test names.* The chapter will also include information on the time limits, numbers of items, and scoring formulas for the tests, as well as a description of their origin and nature, sample items, and raw score frequency distributions. Some attention will be devoted to the selection of variables included to help identify previously established factors.

1. List of Variables

1. Absurdities
2. Arithmetic
3. Block Counting
4. Camouflaged Outlines
5. Cards
6. Circles
7. Conclusions
8. Decoding
9. Designs
10. False Premises
11. Figure Analogies
12. Figure Classification I
13. Figure Classification IIA
14. Figure Classification IIB
15. Figure Series
16. Figures
17. First and Last Letters
18. Forms
19. Geometrical Puzzles
20. Identical Forms
21. Incomplete Outlines
22. Letter Series
23. Logical Puzzles
24. Map Planning
25. Matrices VI
26. Mechanical Information
27. Mechanical Movements

---

*This is a practice that we hope will be followed more frequently in reports of factor analysis studies.

28. Mixed Series
29. Mutilated Pictures
30. Mutilated Words
31. Nim
32. Number Series
33. Numerical Operations I
34. Numerical Operations II
35. Numerical Puzzles
36. Overlapping Circles
37. Painted Blocks
38. Paper Folding
39. Picture Analogies
40. Picture Arrangement
41. Picture Classification
42. Picture-Group Naming
43. Planning a Circuit
44. Practical Situations
45. Progressive Matrices B
46. Progressive Matrices C
47. Progressive Matrices D
48. Progressive Matrices E
49. Reading
50. Reading II
51. Reasons
52. Sentence Order
53. Series
54. Street Gestalt Completion
55. Suffixes
56. Surface Development
57. Things Round
58. Topics
59. Verbal Analogies
60. Verbal Classification I
61. Verbal Classification II
62. Vocabulary
63. Word-Group Naming
64. Word Selection
65. Word Squares
66. Education

2. Factors Affecting Instructions, Numbers of Items, Time Limits, and Scoring Formulas

Each test was accompanied by separately timed instructions, which in almost all cases included provision for one or more practice items. Information on the time limits for the instructions and for the tests themselves, on the numbers of practice items and scored items in the tests, and on the scoring formulas is presented in Table 8 in Appendix II.

For all tests, care was taken to include a sufficient number and variety of fore-exercises to insure insofar as possible that the

subjects would understand the nature of the test tasks. Decision on the number of items for each test was made in the light of all available information on the reliability and score distributions for the same test or similar tests in previous uses. New tests on which no data were at hand were administered in a preliminary form to classes of college students. In many cases this pre-trial served not only to assist in the decisions on numbers of items but also to provide preliminary estimates of appropriate time limits, information on reliability and item difficulty, and evidence of ambignities that could be corrected.

Decisions on test length in terms of number of items of course could not be made independently of decisions on time limits. One consideration governing such decisions was the desirability of encompassing all the tests into five sessions of not more than three hours each in length, with appropriate allowance for rest periods. Although 15 hours seems like a very ample over-all time allowance, it was desired to sample as many facets of reasoning as possible. Numerous types of tests were originally considered for a place in the battery, so that the particular merits of each test and the time it would require had to be weighed against those of other contenders.

The desirability of analyzing as large a battery as possible also meant that some of the single tests could not be long enough to yield the degree of reliability that is regarded as essential for individual diagnosis. As a matter of fact, our plans for this study did not include a determination of the best possible estimate of the reliability of each test for the sample we used. The practice of some investigators of reporting odd-even or Kuder-Richardson reliability coefficients for time-limit tests with a large or an unknown speed component has little to recommend it. Since the common-factor variance would provide a lower limit for the reliability of each test and since with a large number of variables we could afford to admit that our results for a few were not conclusive, it did not seem worth while to expend the resources that would have been required for a best estimate of the reliability of each test.

In any event, this study was designed with the notion of exploring the domain of reasoning as broadly as possible. Even if we had obtained a good estimate of the reliability of all the tests that we considered for inclusion in the study, we still would have decided to include some of low reliability rather than to narrow the scope of the study. It may be reiterated, however, that all available information about the reliability of the tests adapted from other sources was considered in setting test lengths.

As a final check on the clarity of instructions and on the tentative time limits, the entire battery of tests was administered to a group of 10 high-school junior and senior boys. This led to some changes in the tentative time limits and to marked expansion and clarification of the directions for one test and a minor change here and there for others.

The right-most column of Table 8 shows the scoring formulas used. For tests answered in completion form the scoring formula was ordinarily either the number of right answers or the number of responses. For most of the multiple-choice tests the familiar correction for guessing was made. For a few multiple-choice tests, however, where we were repeating tests used in previous factor analyses without correction for guessing (e.g., Progressive Matrices and Number Series) or where the number of choices was large or varied widely from one item to another, we simply counted the number of right answers. It may also be noted that we did not believe it would be worth while to correct for guessing in the instances of the two arrangement tests, Sentence Order and Picture Arrangement.

3. Naming the Tests

A word about the naming of the tests is in order. The names were based on several considerations: (1) It was regarded as undesirable to alter the name of a familiar test or a familiar type of test unless there was good reason to do so. (2) The tests were to be given to a sample of Army enlisted men whose level of verbal ability was not expected to be high. This led us to reduce the vocabulary level of some of the test titles. (3) In no case was it desirable to include the name of a factor and especially the name of a type of reasoning ability in the test title. Thus we referred to "Logical Selection," a subtest of the Terman-McNemar Test of Mental Ability, as "Word Selection," and instead of "Reasoning" we used "Conclusions."

4. Sources of the Tests

The description of each test that is given below indicates its source. In some instances in which tests were developed in one major test-producing agency such as the Psychometric Laboratory of the University of Chicago or the Army Air Forces Aviation Psychology Program, it has not been feasible for us to track the test down to its original constructor. As a matter of fact, probably most tests developed in such agencies reflect the contributions of a number of individuals, so that to name all of them would be manifestly out of the question.

It should be mentioned that, in addition to the authors of this report, the persons who did the major share of the editorial work on the entire battery and the construction of the new tests were Miss Goldie Demb and Mr. Daniel Campbell.

5. Descriptions of the Tests

There follows, in numerical and alphabetical order, a description of each test, accompanied in most cases by a sample item and followed by the frequency distribution of the raw scores.*

---

*As is pointed out in Chapter B, raw scores for all variables were coded in such a manner that their frequency distributions would approximate normality. The raw score ranges and frequencies corresponding to the coded scores for each test are given in Table 10 in Appendix II.

1. Absurdities was patterned after a Thurstone test. Approximately half of the items were newly constructed; some of the Thurstone items were reworded and the sentence structure simplified in an attempt to reduce the loading of this test on the verbal factor. Each item consists of one or two sentences, and the subject indicates whether or not the item makes sense.

Mark an F if the item is foolish and an S if it is sensible.

______ Mrs. Smith has had no children, and
I understand that the same was true
of her mother.

Test 1. Absurdities

Raw Scores	-6 -4	-3 -1	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	27 29	30 32	33 35	36 38	Total
Frequency	2	0	0	3	6	5	13	10	18	24	26	32	29	15	17	200

2. Arithmetic is adapted from a subtest of the Army General Classification Test 8X, DA AGO PRT-1442 made available by the Adjutant General's Office. The items were selected from the original test. An attempt was made to minimize the loading on verbal factors by reducing the vocabulary level and the complexity of sentence structure. The instructions to the subjects were also rewritten. An effort was made to increase the influence of any reasoning factors involved, by omitting or revising items that depend primarily on computational skill rather than on understanding of methods or principles. The problems can be solved by simple arithmetic and/or relations of the rate-time-distance type.

Check the answer which you think is right.

John had a dollar. He spent 80¢. To find out how much John had left, it is necessary to:

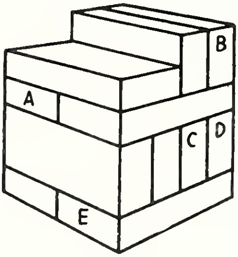
______ add
______ subtract
______ multiply
______ divide

Test 2. Arithmetic

Raw Scores	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Frequency	1	5	6	18	5	26	20	19	11	16	20	16	2	18	7	9	0	1	200

3. Block Counting is Thurstone's adaptation of a test originally developed by T. W. McQuarrie. The test consists of sets of isometric drawings of piles of blocks, some blocks being lettered. The subject reports the number of blocks which each lettered block touches.

Write the number of blocks which each lettered block touches.



A	
B	
C	
D	
E	

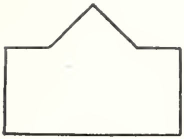
Test 3. Block Counting

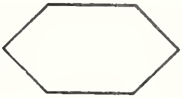
Raw Scores	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	Total
	4	9	14	19	24	29	34	39	44	49	54	59	64	69	74	
Frequency	2	0	4	9	6	20	34	23	30	24	14	13	15	3	3	200

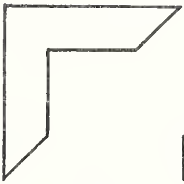
4. Camouflaged Outlines is an abbreviated adaptation of the Army Air Force Qualifying Examination, AC12J, Part II, which is based on figures of the type originally used by Gottschaldt. Each item requires the subject to find the one of five outlines of a simple figure that is embedded within a more complex design. The instructions were completely rewritten and expanded.

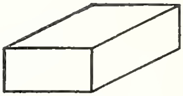
Write the letter of the outline hidden in each figure.

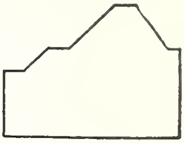
Below are the five simple outlines.

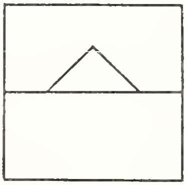

A


B


C


D


E

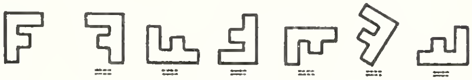


Test 4. Camouflaged Outlines

Raw Scores	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	Total
Frequency	2	9	29	26	26	24	24	17	18	9	1	5	5	2	1	1	0	0	1	200

5. Cards was developed by Thurstone. The test contains rows of seven two-dimensional diagrams representing cards. The subject reports whether or not each of the last six diagrams in a row shows the same side of the card as the first one in the row.

> In each row, mark every card that is like the first card in the row.

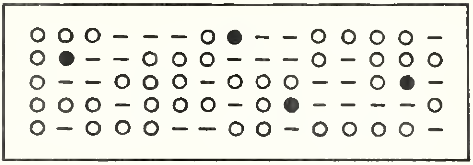


Test 5. Cards

Raw Scores	-8	0	8	16	24	32	40	48	56	64	72	80	88	96	Total
	-1	7	15	23	31	39	47	55	63	71	79	87	95	103	
Frequency	6	6	6	8	17	29	31	31	25	16	12	8	2	3	200

6. Circles is a subtest of the Blakey-Brown Non-Verbal Reasoning Test, Test 8, which was patterned after the Marks test of Thurstone. Each item consists of five rows of circles and dashes. One circle in each of the first four rows is marked according to some rule. The subject is to discover the rule and apply it by making an "X" through the correct circle in the last row.

Figure out the rule and mark the circle in the bottom line that should be black.



Test 6. Circles

Raw Scores	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Frequency	10	6	12	7	10	7	11	14	11	11	11	15	20	18	20	17	200

7. Conclusions is a shortened form of Thurstone's Reasoning test in a form made available to us by W. A. Botzum. The instructions were amplified. Each item contains from one to three sentences. The subject is to judge whether or not the conclusion follows from the rest of the argument, without regard for whether or not the argument is sensible.

Mark plus (+) for good arguments, minus (-) for bad arguments.

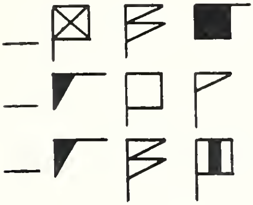
All wealthy men have automobiles, and he is wealthy. Therefore he must have an automobile. _____

Test 7. Conclusions

Raw Scores	-14 -13	-12 -11	-10 -9	-8 -7	-6 -5	-4 -3	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	Total
Frequency	1	3	2	9	21	32	38	30	18	25	11	5	4	0	1	200

8. Decoding is a shortened form of the Army Air Force Classification Program Test CI214AX2. The instructions were reworded, and a separate answer sheet was not used. Each problem required decoding a group of six three- or four-letter words. The code symbols are signal flags which are arranged next to the words, and the subject's task is to find the row of flags which corresponds to each word.

In the space to the left of each group of flags, write the letter which corresponds to the correct word.



(A) bud

(B) hug

(C) bat

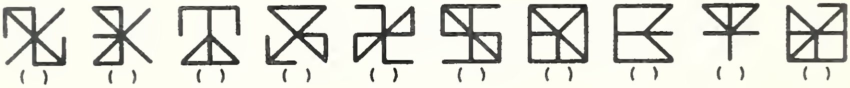
Test 8. Decoding

Raw Scores	-9 -7	-6 -4	-3 -1	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	27 29	30 32	33 35	36 38	39 42	Total
Frequency	1	7	20	31	23	23	20	11	11	16	6	19	6	1	1	2	2	200

9. Designs was developed in Thurstone's laboratory. We modified the instructions and also the scoring, as will be explained later. The subject is given a single figure resembling an upper-case Greek "sigma" as a model. His problem is to examine each of 300 designs and indicate for each design whether or not it contains the figure.

Put an "X" under each design that contains the model.

"Model"



Test 9. Designs

Raw Scores	0 17	18 35	36 53	54 71	72 89	90 107	108 125	126 143	144 161	162 179	180 197	198 215	216 233	234 251	Total
Frequency	7	13	26	23	17	37	22	9	10	7	7	16	0	6	200

10. False Premises was prepared in Thurstone's laboratory with the assistance of Merrill Roff. The instructions were modified to include more explanation of the task, and several test items were omitted. The subject is required to test the validity of verbal syllogisms, the premises of which are obviously false or absurd.

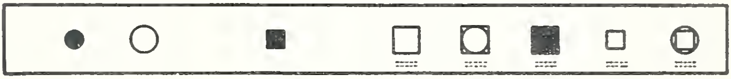
> Mark plus (+) if the argument is sound and minus (-) if it is not.
>
> All pigs can fly. All elephants are pigs. Therefore all elephants can fly. ____

Test 10. False Premises

Raw Scores	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	Total
	-11	-9	-7	-5	-3	-1	1	3	5	7	9	11	13	15	17	
Frequency	1	1	3	3	11	18	19	36	29	33	24	6	11	2	3	200

11. Figure Analogies was adapted by Thurstone from a similar test in the American Council on Education Psychological Examination. For each item three figures are given; and the subject chooses from among five additional figures the one which bears the same relation to the third figure as the second figure bears to the first.

> Find the rule by which the first figure is changed to make the second. Apply the rule to the third figure. Mark the resulting figure at the right.

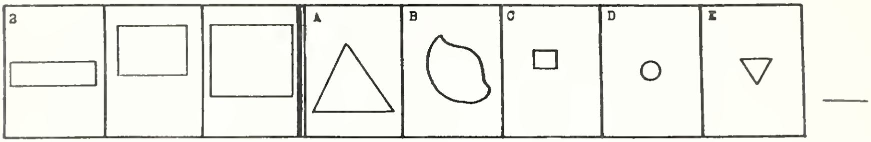


Test 11. Figure Analogies

Raw Scores	-6	-3	0	3	6	9	12	15	18	21	24	27	Total
	-4	-1	2	5	8	11	14	17	20	23	26	29	
Frequency	2	12	23	10	9	14	28	37	26	24	13	2	200

12. Figure Classification I is an abbreviated form of the Army Air Force Psychology Program Test CI213AX1, Part I. Each item contains a group of three figures that are alike in some way. The subject is to find the criterion of similarity and choose from five additional figures the one which is like those in the group of three.

In the space to the right of each of the following problems, place the letter which corresponds to the figure which is like the three at the left.

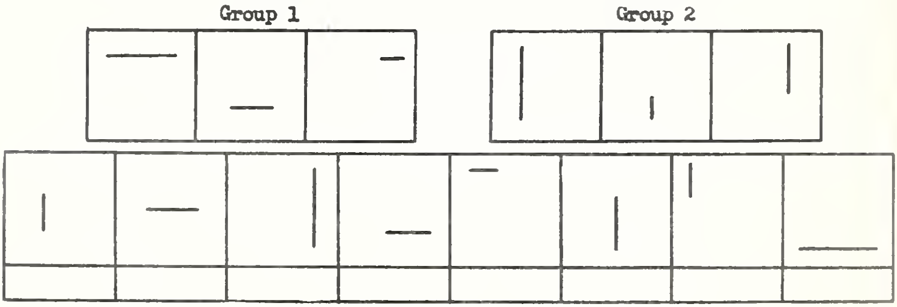


Test 12. Figure Classification I

Raw Scores	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Frequency	1	0	5	0	8	19	20	32	4	30	25	22	11	6	9	3	3	1	0	1	200

13. Figure Classification II, Part A is essentially an adaptation of Thurstone's test of the same name. The instructions were amplified and some new items included. Sets of two groups of three figures, the figures of each group being alike in some way, are presented. For each set, the subject is to classify each of eight additional figures into one of the two groups.

Under each figure write the number of the group to which it belongs.



Test 13. Figure Classification II A

Raw Scores	-45 -37	-36 -28	-27 -19	-18 -10	-9 -1	0 8	9 17	18 26	27 35	36 44	45 53	54 62	63 71	72 80	81 89	Total
Frequency	1	1	0	2	0	4	14	34	42	37	26	16	12	6	5	200

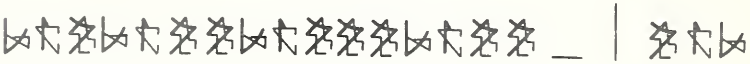
14. Figure Classification II, Part B is similar to Figure Classification II, Part A, except that sets of three groups of three similar figures each are presented, and the subject classifies each of eight additional figures into one of the three groups. The items for this test were newly constructed.

Test 14. Figure Classification II B

Raw Scores	-5	0	5	10	15	20	25	30	35	40	45	50	55	60	65	Total
	-1	4	9	14	19	24	29	34	39	44	49	54	59	64	69	
Frequency	4	11	8	10	34	40	29	14	18	8	12	3	5	3	1	200

15. Figure Series is similar to Test 7 (the Form Series test) of the Blakey-Brown Non-Verbal Reasoning Test. The underlying principles of the items were the same, but the type of figure used was changed in order to reduce the possibility of the subjects' solving the problem through verbalization. The instructions were also changed. Each of the items contains a series of differently shaped figures, each figure being repeated several times. The subject fills in a blank in the series with the correct figure, according to the rule by which the series is ordered.

Underline the figure to the right which should go in the blank space.

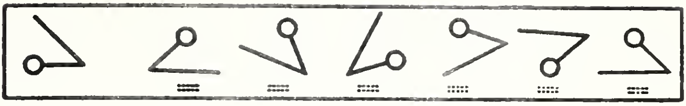


Test 15. Figure Series

Raw Scores	-4	-2	0	2	4	6	8	10	12	14	16	18	20	22	Total
	-3	-1	1	3	5	7	9	11	13	15	17	19	21	23	
Frequency	1	7	11	12	25	32	26	38	16	14	14	3	0	1	200

16. Figures was developed by Thurstone. Each item consists of a row of seven figures all having the same shape as the first in the row. Some are mirror images of the first one, and all are turned in different directions. The subject finds those that would look exactly like the first one if they were turned right side up, i. e., those that are not mirror images of it.

In each row place a mark under every figure which is like the first figure in the row.



Test 16. Figures

Raw Sc.	-45	-36	-27	-18	-9	0	9	18	27	36	45	54	63	72	81	90	99	108	Total
	-37	-28	-19	-10	-1	8	17	26	35	44	53	62	71	80	89	98	107	116	
Frequency	2	0	0	2	3	10	17	15	15	25	27	19	27	17	13	5	2	1	200

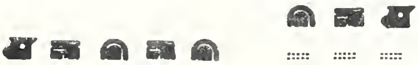
17. First and Last Letters was devised by T. G. Thurstone. We changed the instructions somewhat. In the test proper, the subject was asked to write as many words as he could think of which begin with a certain letter and end with a certain letter.

Test 17. First & Last Letters

Raw Scores	0	2	4	6	8	10	12	14	16	18	20	22	24	Total
	1	3	5	7	9	11	13	15	17	19	21	23	25	
Frequency	1	10	21	47	43	30	17	19	7	2	1	1	1	200

18. Forms is Coombs' adaptation of Thurstone's ABC test, in which geometrical designs were substituted for different letters. There are two rules by which three different forms are combined: (1) A combination of any two of the forms is equal to the third form. (2) If a form is combined with itself the combination is equal to that form. Each item involves applying these two rules serially to a row of five forms. The first two forms are combined according to the rules above, the result is combined with the third form, and so on.

Place a mark in the proper space to indicate your answer.



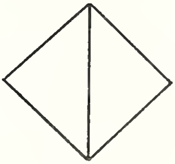
Test 18. Forms

Raw Scores	-12	-8	-4	0	4	8	12	16	20	24	28	32	36	40	44	Total
	-9	-5	-1	3	7	11	15	19	23	27	31	35	39	43	47	
Frequency	3	16	26	39	34	25	18	8	6	8	1	6	3	4	3	200

19. Geometrical Puzzles is a new test consisting of geometrical puzzles, most of which are variations on problems such as those which involve drawing figures with one continuous line, using a given number of matches to build a figure with a given number of squares, etc.

Show your solution to the following problem.

It is possible to draw the figure below with one continuous line. Show how this could be done by copying the drawing in the blank space to the right. Leave the corners unjoined so that it is possible to see how you drew the figure.

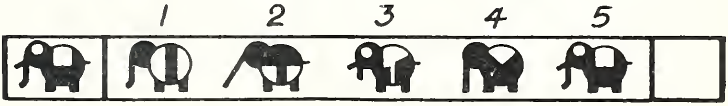


Test 19. Geometrical Puzzles

Raw Scores	0	1	2	3	4	5	6	7	Total
Frequency	7	31	49	54	40	9	8	2	200

20. Identical Forms was made available by Thurstone. Each item contains six figures, and the subject's task is to choose the one which is identical with the first figure.

Write the number of the figure which is exactly the same as the first figure in the line.



Test 20. Identical Forms

Raw Scores	-4 -1	0 3	4 7	8 11	12 15	16 19	20 23	24 27	28 31	32 35	36 39	40 43	44 47	48 51	52 55	Total
Frequency	2	3	2	1	6	10	20	39	53	27	16	13	4	2	2	200

21. Incomplete Outlines contains some items from the Cooperative English Test, Test B1, Part III, Effectiveness of Expression (used with the permission of the Educational Testing Service), and some newly constructed items. Outlines such as one might use in writing a magazine article are presented, but some subtopics or subordinate headings are omitted. For each omission, the subject chooses from five alternatives the phrase that would best complete the outline at the indicated point.

Test 21. Incomplete Outlines

Raw Scores	-6	-3	0	3	6	9	12	15	18	21	24	27	30	33	36	Total
	-4	-1	2	5	8	11	14	17	20	23	26	29	32	35	38	
Frequency	1	5	31	37	42	19	18	15	8	10	6	3	3	0	2	200

22. Letter Series was developed by the U. S. Employment Service. Each problem requires the subject to find the rule according to which a series of seven letters is arranged, and then to extend the series by adding one more letter.

Test 22. Letter Series

Raw Scores	0	2	4	6	8	10	12	14	16	18	20	22	Total
	1	3	5	7	9	11	13	15	17	19	21	23	
Frequency	5	11	17	25	17	37	33	22	16	7	7	3	200

23. Logical Puzzles contains items selected from two tests made available by W. A. Botzum, Reasoning II and Reasoning III. The tests consist of verbally presented puzzles, the answers to which do not appear directly from the information given but must be deduced from it. In the selection of the problems, all which appeared likely to depend directly on factors involving numerical or spatial abilities were omitted.

Check the answer which you think is correct.

Jack said, "If Henry comes today, I shall go hiking or swimming. If Paul comes today, I shall go riding or hiking." Both Henry and Paul came. What do you think all three of them did?

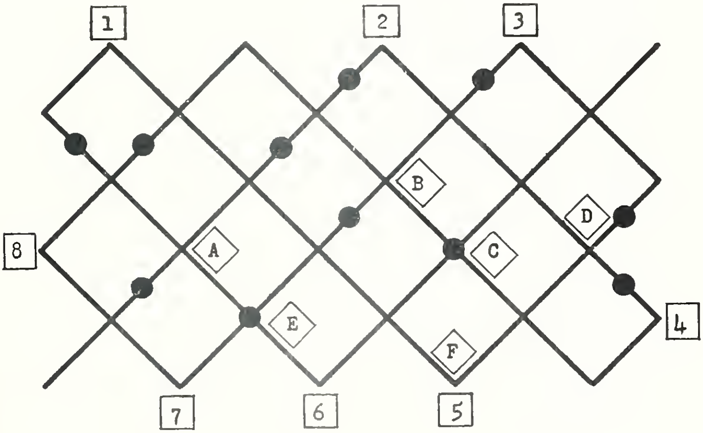
________ swimming
________ riding
________ hiking

Test 23. Logical Puzzles

Raw Scores	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
Frequency	2	5	5	12	16	17	18	27	15	30	17	12	15	4	3	2	200

24. Map Planning is patterned after TEST CI412X from the Army Air Force Aviation Psychology Program. Each item involves the planning of a route between two points on a maze-like map. The "route" must be the shortest possible route that avoids blocks "damaged by bombs," as indicated by black circles. We had all the problems redrafted to use single straight lines and black circles in an attempt to minimize loadings on perceptual and visualization factors, which have been reported for this test in Air Force studies. We also attempted to simplify the instructions.

Write in each blank the letter showing the building you must pass.



Find the shortest route from:

____ 3 to 5

____ 4 to 6

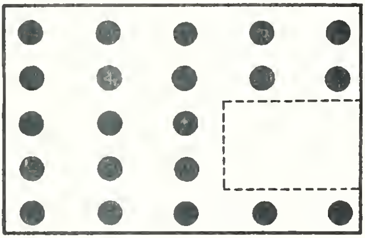
____ 1 to 7

Test 24. Map Planning

Raw Scores	-12 -9	-8 -5	-4 -1	0 3	4 7	8 11	12 15	16 19	20 23	24 27	28 31	32 35	36 39	40 43	44 47	Total
Frequency	3	3	10	13	7	9	10	18	23	29	25	24	13	12	1	200

25. Matrices VI was adapted from TEST G-4 developed and made available by the British Air Ministry. All the drafting was redone. Written instructions were substituted for the oral instructions given by the examiner in the original form of the test. Each item consists of a square or rectangular design, the parts of which are arranged in a regular or sequential order according to some rule. A rectangular piece is omitted from the design, which the subject is required to fill in. It was our desire to use this test exactly as used by the British Air Ministry, since William Stephenson, who worked on the original form of the test, considers it to be a very good measure of Spearman's "g." Hence we used separate time limits for each of the four pages of the test proper. We made no changes in the items except to redraft them for clearer presentation, even though we believed that the very composition of the test was conducive to factorial complexity.

Draw in the missing part of the pattern.



Test 25. Matrices VI

Raw Scores	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	27 29	30 32	33 35	36 38	39 41	42 44	45 47	Total
Frequency	1	1	3	8	23	14	33	13	31	23	12	18	8	6	4	2	200

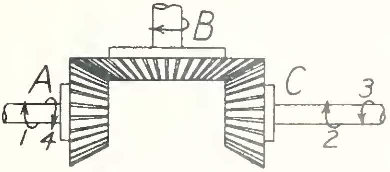
26. Mechanical Information is the Army Air Force Classification Test CI905A with several minor variations. The items (five-choice) demand knowledge in the field of mechanics, especially automotive mechanics, and they include questions about the structure and function of machines and the diagnosis of difficulties.

Test 26. Mechanical Information

Raw Scores	-4 -3	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	Total
Frequency	6	11	27	25	27	23	22	19	10	6	12	3	3	1	5	200

27. Mechanical Movements is an abbreviated form of a test developed by Thurstone. The items are based on diagrams containing several gears, cams, pulleys, shafts, rollers, etc. The direction of movement of several of the parts is indicated by arrows. Several questions pertaining to the relative speed, direction of movement, possible combinations of parts which will allow operation, etc., are asked about each diagram.

Underline the answers to the questions after each of the pictures.



A, B, and C are three bevelled gears.

1. If A is turning in direction 1, which way is C turning? 2 3

2. If B is turning in the direction shown, which way is A turning? . . 1 4

3. If B is turning in the direction shown, which way is C turning? . . 2 3

Test 27. Mechanical Movements

Raw Scores	-18 -16	-15 -13	-12 -10	-9 -7	-6 -4	-3 -1	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	Total
Frequency	1	3	1	11	28	21	41	26	30	22	11	2	2	0	1	200

28. Mixed Series is a lengthened and modified version of the Abstraction test of the Shipley Institute of Living Scale. The 20 items in the original test were used with permission from the Institute and 20 additional items were newly constructed. The items are series of different kinds--number, letter, geometrical, and a variety of verbal series, each ordered according to a different rule. The subject is required to extend the series one unit.

Write the answers in the blanks.

A A B B C C D D _ _

■ □ ▲ △ ● __

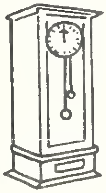
Test 28. Mixed Series

Raw Scores	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	Total
Frequency	2	1	8	18	18	26	27	25	30	15	15	6	4	3	2	200

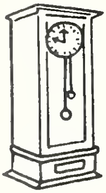
29. Mutilated Pictures is Thurstone's test. Each item contains two pictures identical in every respect except that some part in one of the pictures has been erased. The subject is to indicate the picture in each pair which has something missing.

Place a mark through the picture that has had some part erased.

A



B

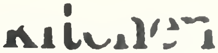


Test 29. Mutilated Pictures

Raw Scores	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	Total
Frequency	1	1	4	11	25	32	39	39	20	12	4	8	1	1	2	200

30. Mutilated Words was developed by Thurstone. We used the paper-and-pencil form of the test. Each item consists of a word with parts of the letters effaced. The subject is to identify the complete word.

Write the word on the line.



Test 30. Multilated Words

Raw Scores	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Frequency	1	4	5	7	9	24	16	17	13	26	14	11	17	13	13	4	1	3	1	1	200

31. Nim was devised especially for this battery. It is a pencil-and-paper reproduction of a game played by two people with matches or other markers. A number of matches are arranged in rows. Players alternately pick up as many matches from any one row as they want to. The object is to force the opposing player to pick up the last match. For each item in this test, the subject marks through the matches that he would take if it were his turn, in order to win the game; or, if it is impossible for him to win, he writes an "X" beside the problem.

Test 31. Nim

Raw Scores	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Frequency	10	16	16	25	19	20	27	16	19	12	9	4	2	2	1	2	200

32. Number Series was developed by Thurstone. The instructions have been revised and amplified to reduce their level of verbal difficulty. Each problem consists of a series of numbers with one or more missing numbers within the series. The subject's problem is to find the rule according to which each series is ordered and to indicate the number that would follow at the end of the series.

> Find the rule in the problem below, and mark the answer which should go where the "X" is.

Problem	Answers
16 17 19 ___ 22 23 ___ X	22 24 25 26 28

Test 32. Number Series

Raw Scores	-4 -3	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	Total
Frequency	5	4	13	21	32	31	39	23	22	9	1	200

33. Numerical Operations I is the Army Air Force Classification Test, CI702B, Part I. The items are simple problems of addition and multiplication.

Check the space labeled C if the answer is correct and the space labeled W if it is wrong.

Add	C	W
6 + 2 + 1 = 5	____	____
2 + 5 + 7 = 14	____	____
13 + 8 + 2 = 24	____	____

Add

$$\begin{array}{r}38\\3\\\underline{69}\\110\end{array}\qquad\begin{array}{r}16\\18\\\underline{7}\\45\end{array}$$

C ____ ____
W ____ ____

Multiply

$$\begin{array}{r}7\\\underline{2}\\14\end{array}\quad\begin{array}{r}3\\\underline{5}\\13\end{array}\quad\begin{array}{r}4\\\underline{4}\\16\end{array}$$

____ ____ ____ C
____ ____ ____ W

Test 33. Numerical Operations I

Raw Scores	4 7	8 11	12 15	16 19	20 23	24 27	28 31	32 35	36 39	40 43	44 47	48 51	52 55	56 59	60 63	Total
Frequency	1	7	14	13	25	23	24	24	27	17	10	6	4	3	2	200

34. Numerical Operations II is the Army Air Force Classification Test CI702B, Part II. The items are simple problems of subtraction and division.

Underline the answer which you think is right.

Subtract	Answers
6 - 2 =	1 6 4 3 7
18 -16 =	2 4 7 6 9

Subtract	Ans.		Ans.
$\begin{array}{r}78\\\underline{16}\end{array}$	52 67 68 66 62	$\begin{array}{r}89\\\underline{35}\end{array}$	35 69 54 58 59

Divide	Answers
6 ÷ 2 =	2 3 7 4 9
9 ÷ 3 =	6 7 4 2 3

Test 34. Numerical Operations II

Raw Scores	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 74	Total
Frequency	1	8	16	33	34	40	19	15	17	12	2	1	1	0	1	200

35. Numerical Puzzles is a new test consisting of puzzles from a variety of sources, such as the Thurstone Ingenuity Test, magazines like Coronet, etc. Although the problems require numerical ability, an attempt was made to select problems that could not be solved more readily by recourse to algebra than without its use.

For each item, check or write an answer.

The lights go out as a man is packing for a hurried trip. In his closet are 5 pairs of shoes, each pair slightly different. How many shoes must he throw in his bag to make sure of having at least one matching pair?

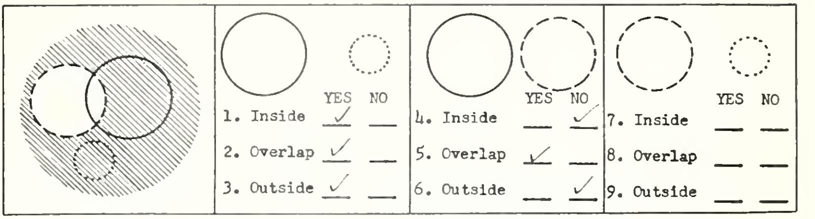
______ 2
______ 3
______ 5
______ 6
______ 10

Test 35. Numerical Puzzles

Raw Scores	0	1	2	3	4	5	6	7	8	Total
Frequency	4	18	44	57	45	20	8	3	1	200

36. Overlapping Circles, which was constructed by Mr. John Hanson, is a new test consisting of problems involving three circles: a dotted, a broken, and a solid circle. Each set of problems is based on a different main diagram showing the three circles and some shaded area. The rules provide that the dotted circle can move any place in the shaded area and that it cannot enter or cross over any white area. Nothing else in the diagram can move. Each item asks a question about whether one circle can be inside, be outside, or overlap another circle. The test requires rather lengthy directions and the nature of the problems was found upon pre-trial to be difficult to explain. It was thought, however, that the test might get at an ability like that involved in verbal syllogistic reasoning but with less emphasis on the verbal component.

For each question, check "Yes" or "No."



MAIN DIAGRAM SET I SET II SET III

Test 36. Overlapping Circles

Raw Scores	-14 -8	-7 -1	0 6	7 13	14 20	21 27	28 34	35 41	42 48	49 55	56 62	63 69	70 76	77 83	84 90	Total
Frequency	4	15	35	35	28	16	11	11	5	11	11	7	5	3	3	200

37. Painted Blocks is adapted from Spatial Visualization II, CI203A, used by the Army Air Force. The instructions were changed, and some of the problems from Part II of the original test were eliminated. Verbal descriptions are given of various solid blocks, some of the faces of which are painted in different colors and which are cut into parts in different ways. The subject is required to imagine how the blocks look both before and after they are cut, and to answer questions about the sizes and colors of the resulting parts.

The ends of a block of wood 1" X 1" X 3" are painted black and the block is then cut into 1-inch cubes.

_____ How many 1-inch cubes are there?

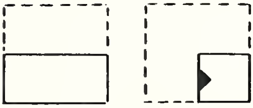
_____ How many 1-inch cubes have one side painted black?

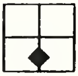
Test 37. Painted Blocks

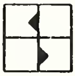
Raw Scores	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	Total
Frequency	43	65	46	21	10	7	3	2	1	0	1	1	200

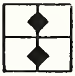
38. Paper Folding is adapted from the Army Air Force Test, Spatial Visualization I, CI204AX2. The instructions were somewhat changed and the last 10 problems were eliminated. In each item two or three drawings illustrate step by step how a square, circular, or triangular piece of paper is folded and cut. The subject chooses from five drawings of unfolded pieces of paper the one that correctly shows all the creases and holes made by folding and cutting.

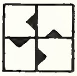
Draw a line under the figure which shows how the piece of paper will look when it is unfolded.

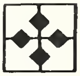



A


B


C


D

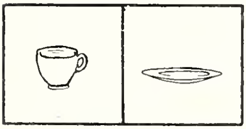

E

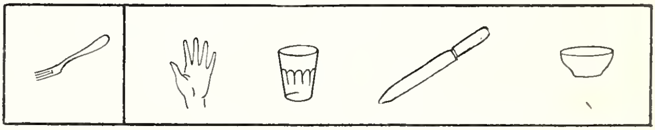
Test 38. Paper Folding

Raw Scores	-4 -3	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	Total
Frequency	13	15	26	16	41	14	18	13	7	14	9	3	6	1	2	2	200

39. Picture Analogies is a new analogies test based on pictures of meaningful objects. Three pictures are shown, and the subject chooses from among four additional pictures the one which bears the same relation to the third picture as the second picture bears to the first.

Put a large "X" through the picture that completes the second pair.



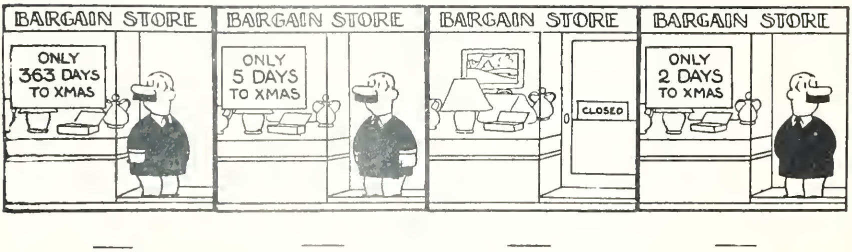


Test 39. Picture Analogies

Raw Scores	-8 -7	-6 -5	-4 -3	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	Total
Frequency	1	1	2	2	6	10	35	29	48	22	20	11	11	1	1	200

40. Picture Arrangement is a new test that requires the subject to reconstruct the order of individual pictures in a comic-strip sequence. The items are similar to the "Little King" items in the Wechsler-Bellevue test but were based on pictures from "Louie" which were adapted with the permission of Press Features, Inc. Each item consists of four panels of a disarranged comic strip. The subject is to arrange them so that they form a logical sequence.

Place a "1" under the picture that should come first, a "2" under the picture that should come second, and so on.

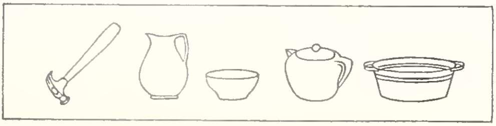


Test 40. Picture Arrangement

Raw Scores	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Frequency	1	0	0	3	2	12	10	9	13	24	26	16	24	21	11	13	11	2	2	200

41. Picture Classification was made up of items from various sources, including the Non-Language Multi-Mental Test, the Science Research Associates Non-Verbal Form, and the California Test of Mental Maturity (used with the permission of the Teachers College Bureau of Publications, Science Research Associates, and the California Test Bureau, respectively). Each item contains five pictures, four of which form a group with a certain characteristic in common. The subject is to cross out the one picture that does not belong with the other four.

Put a large "X" through the one picture that does not belong with the rest.

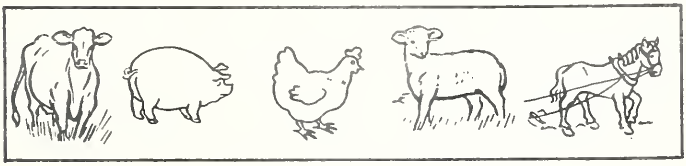


Test 41. Picture Classification

Raw Scores	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	Total
Frequency	1	3	7	9	13	35	31	24	29	23	10	11	1	2	1	200

42. Picture-Group Naming is a new test in which each item presents a group of five pictures of meaningful objects that are alike in some way. The subject is to assign to the group a name under which all of the objects pictured could be subsumed. The directions specify that the class name should constitute the least general description possible that will include all the objects pictured.

Write the best name for the group.



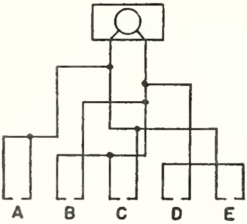
____

Test 42. Picture-Group Naming

Raw Scores	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
Frequency	1	1	3	6	11	9	15	12	20	26	25	22	10	8	11	6	7	5	2	200

43. Planning a Circuit is adapted from the Army Air Force Qualification Test AC12J. The directions were considerably modified in an effort to make the task clear to our subjects. Each item is based on an electrical-circuit diagram which includes a "meter" and insulated "wires" leading to it from several sets of terminals. The subject is to decide at which of five pairs of terminals a battery would have to be placed to operate the meter.

Underline a letter to show where a battery should be placed.



Test 43. Planning A Circuit

Raw Scores	-6	-4	-2	0	2	4	6	8	10	12	14	16	18	20	22	Total
	-5	-3	-1	1	3	5	7	9	11	13	15	17	19	21	23	
Frequency	8	22	16	30	17	30	15	12	12	11	11	8	5	2	1	200

44. Practical Situations contains items taken from Army Air Force Practical Judgment Tests, CI301BX3 and CI301C. Each item presents verbally a practical problem. The subject is required to choose the best solution from five alternatives. In the selection of items, an effort was made to exclude items that seemed to require a significant degree of spatial ability or mechanical experience. No fore-exercise is given since each problem is different, and a sample would therefore serve only to illustrate how to mark answers for multiple-choice items.

Test 44. Practical Situations

Raw Scores	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Frequency	1	0	0	0	2	2	7	16	19	17	37	32	21	18	11	14	2	1	200

45-48. Progressive Matrices is J. S. Raven's test, which consists of five sets (A, B, C, D, and E) of 12 items each. The sets are scored separately but administered with an over-all time limit. Although our subjects took the entire test, inspection of available score distributions revealed such a preponderance of high scores on the easy items of Set A that we did not plan to treat it as a variable in this study. We used Sets B through E as variables 45 through 48,

respectively. Each of the items in this test presents a regular geometric pattern, either symmetrical or changing systematically according to some rule. A part of the pattern is omitted, and the subject is to choose from a number of alternatives the one which would best fill in the pattern. It should be mentioned that on the basis of pre-trial results we set the time limit for the test at 40 minutes, but instructed our examiner to extend the time to 50 minutes if most subjects had not finished or were not working on Set E at the end of 40 minutes. The examiner found that the subjects became very restless during the test and felt that it was wise to call time at the end of 26 minutes, although a number of subjects had not completed Set E. This circumstance probably accounts for some of our findings for variables 45-48.

45-B. Each item shows three discrete figures arranged as three corners of a square. The correct figure for the fourth corner must be chosen from six alternatives. An analogous relationship exists both horizontally and vertically among the four corners.

Test 45. Progressive Matrices B

Raw Scores	1	2	3	4	5	6	7	8	9	10	11	12	Total
Frequency	1	1	1	2	4	6	9	15	20	38	49	54	200

46-C. Each item consists of a three-by-three array of figures, the one at the intersection of the third row and third column being chosen by the subject from eight alternatives. In any row or column, the first figure is changed in a certain way to produce the second and the second changed in the same way to produce the third. The answer must be found by discovering the rule of progression. In the more difficult items, there are both vertical and horizintal progressions which must be carried out simultaneously. The kinds of rules involved are increasing or decreasing the size, the number of component elements, or the distance between elements, of a figure.

Test 46. Progressive Matrices C

Raw Scores	1	2	3	4	5	6	7	8	9	10	11	12	Total
Frequency	1	2	4	3	9	8	20	34	51	44	21	3	200

47-D. Another kind of sequence occurs in the items of this part. Rather than being formed from each other by a discoverable operation, the figures appear to be arbitrarily given and the subject has to discover the rules by which the same things recur in each row or column. Complication is introduced by having component parts or relations of the figure vary separately. Many of the items in this section are geometrical counterparts of Latin squares or Graeco-Latin squares.

Test 47. Progressive Matrices D

Raw Scores	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Frequency	1	2	2	3	5	13	18	28	33	36	42	13	4	200

48-E. In this part, the first and second figures in each row and column are combined to produce the third figure. The types of combination are addition or cancellation or a mixture of the two. For example, lines common to the first two figures may cancel each other and non-common lines combine to produce the third figure.

Test 48. Progressive Matrices E

Raw Scores	0	1	2	3	4	5	6	7	8	9	10	Total
Frequency	16	16	31	34	29	24	22	8	14	4	2	200

49. Reading is a test constructed from material in two of the Chicago Reading Tests, the Preliminary Test C3 and D2, which were prepared under the direction of Max D. Engelhart and T. G. Thurstone. The test consists of a number of paragraphs, on each of which two multiple-choice questions are based. The instructions and some of the questions were revised.

Test 49. Reading

Raw Scores	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	Total
Frequency	1	2	2	14	27	31	40	25	16	14	12	9	5	2	200

50. Reading II is made up of items based on three passages taken from the Cooperative English Test C1: Reading Comprehension, Form Q (used with permission from Educational Testing Service), and two from the Air Force Judgment and Reasoning Test. Some of the questions were revised. The intention in the construction of the items was to emphasize the ability to draw inferences. It may be wondered why this test was included in addition to the Reading test used as variable 49. Our purpose was to throw some light on the claim that such items as are included in the test measure an ability that has been called "reasoning in reading."*

Test 50. Reading II

Raw Scores	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Frequency	1	11	14	19	18	24	20	15	14	10	11	10	15	9	3	0	2	4	200

51. Reasons is a new test consisting of two questions similar to "Why do many people live in cities?." The subject is given two minutes to write as many answers as he can think of to each question. The score was simply the number of reasons given for both questions, regardless of their quality.

Test 51. Reasons

Raw Scores	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	Total
Frequency	1	2	17	23	27	24	28	24	21	14	9	3	6	0	0	1	200

52. Sentence Order is a new test containing items of the same form as that of the Picture-Arrangement test, variable 40. Each item consists of three sentences which are to be arranged by the subject in a sensible order.

> Place a "1" before the sentence that should come first, a "2" before the one that should come second, and a "3" before the one that should come third.
>
> ______ He dressed and hurried to work.
> ______ He worked hard and was tired when he got home that evening.
> ______ He woke up when the alarm rang.

---

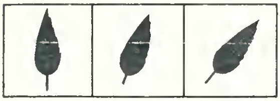
*Guilford, J. P. (Ed.) Printed classification tests. Army Air Forces Aviation Psychology Program, Report No. 5, pp. 142-155.

Test 52. Sentence Order

Raw Scores	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	Total
Frequency	1	2	5	16	30	38	34	32	22	8	11	1	200

53. Series is an adaptation of Part III of R. B. Cattell's A Culture-Free Test, with new instructions (used with the permission of the Psychological Corporation). Each item consists of an ordered series of three or four figures, most of which are geometrical or other very simple figures. The subject is to choose from six alternatives the figure that would properly extend the series.

In the blank space at the right, write the letter of the figure which goes next in the series.



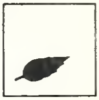
A

B

C

D

E

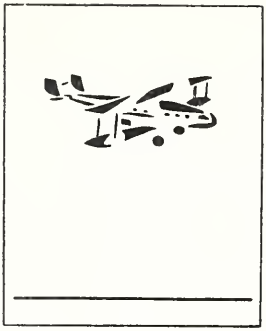

F

Test 53. Series

Raw Scores	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Frequency	2	3	4	5	8	12	14	15	21	13	33	26	21	11	6	3	2	0	1	200

54. Street Gestalt Completion was used in a form made available by Thurstone. Each item is a silhouette of a familiar object with parts deleted, and the subject's task is to identify the figure.

Identify the picture.



Test 54. Street Gestalt Completion

Raw Scores	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Frequency	1	0	0	3	3	9	15	18	18	34	23	23	17	15	12	5	4	200

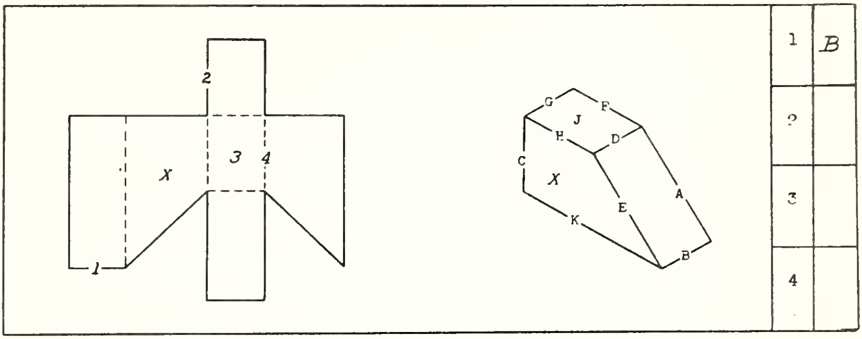
55. Suffixes was originated by Thurstone. The subject is to write as many words as he can that end in a given suffix.

Test 55. Suffixes

Raw Scores	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	Total
Frequency	4	11	25	26	27	33	19	20	14	11	4	2	0	1	3	200

56. Surface Development is based on a test form developed by Thurstone. Our form was adapted from a longer test used in his study of mechanical aptitude. Each item consists of two drawings, one a flat layout with dotted lines representing folds, and the other an isometric drawing of the solid figure which would result if the layout were folded. An "X" is placed on one of the corresponding surfaces of each drawing. Most of the surfaces and edges of the solid figure contain letters. Four of the edges or folds of the layout contain the numbers 1, 2, 3, and 4. The subject is to find the edge or surface on the solid figure that corresponds to each of the four numbered edges or folds in the layout. Our test consisted of four items based on each of nine diagrams.

Write the correct letter in the space beside each number.



Test 56. Surface Development

Raw Scores	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	27 29	30 32	33 35	36 38	39 41	42 44	45 47	Total
Frequency	5	15	34	31	28	25	21	13	8	6	6	5	0	2	0	1	200

57. Things Round is a test by C. W. Taylor with revised instructions. The subject is asked to write as many things as he can think of which are round or could be called round.

Test 57. Things Round

Raw Sc.	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	Total
Freq.	1	3	9	18	25	23	32	13	28	17	13	4	4	4	2	3	1	200

58. Topics is a test by C. W. Taylor with revised instructions. The subject is asked to list as many ideas as he can think of about the topic "A Man Going Up a Ladder."

Test 58. Topics

Raw Scores	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	Total
Frequency	2	8	27	38	42	27	17	25	5	2	2	3	0	0	0	0	1	1	200

59. Verbal Analogies includes a selection of items that were made available by the Adjutant General's Office and originally supplied to them by Thurstone, a few items made available by W. A. Botzum, and 21 newly constructed items. In the selection or construction of the items, we attempted to keep the vocabulary difficulty level fairly low. New instructions were used. For each item, three words are given, and the subject chooses from among four additional words the one which bears the same relation to the third word as the second word does to the first.

Underline the word that completes the second pair.

SKY - BLUE : GRASS - earth green path blue

Test 59. Verbal Analogies

Raw Scores	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	Total
Frequency	4	4	6	6	12	3	14	12	13	14	13	16	19	17	17	7	13	3	7	200

60. Verbal Classification I is partially based on a test prepared by T. G. Thurstone. Our adaptation involved a modification of the instructions and form of presentation of the items, and many new items. For each set of six test words, two groups of four words each were presented to define two categories. The subject is required to place each of six test words into one group or the other according to the classificatory criterion that it fits. It was hoped that the form of presentation that we devised might reduce the factorial complexity of this test. In particular, we wished to use a form that would place less dependence on perceptual and spatial abilities than has been reported for the original form of the test. An attempt was also made to simplify the vocabulary with a view to reducing the loading of this test on the verbal comprehension factor.

For each test word, put a check in the blank next to the list to which it belongs.

	____	inside	____	
HOLE	____	wire	____	STICK
DEEP	____	cane	____	LONG
WITHIN	____	cave	____	LEG
CENTER	____	below	____	STRETCH
	____	down	____	

Test 60. Verbal Classification I

Raw Scores	-60 -49	-48 -37	-36 -25	-24 -13	-12 - 1	0 11	12 23	24 35	36 47	48 59	60 71	72 83	84 95	96 107	108 119	120 131	132 143	144 155	Total
Frequency	1	0	1	3	10	14	25	20	19	21	15	19	14	14	6	6	4	8	200

61. Verbal Classification II is composed of items of the same type as those in Verbal Classification I, but more difficult, as determined by the results of a tryout on college students. It was thought that any reasoning components might have different weights on the more difficult test.

Test 61. Verbal Classification II

Raw Scores	-56 -43	-42 -29	-28 -15	-14 -1	0 13	14 27	28 41	42 55	56 69	70 83	84 97	98 111	112 125	126 139	Total
Frequency	2	1	3	14	14	30	21	24	20	29	20	9	7	6	200

62. Vocabulary is a shortened form of the AGO Classification Test, 8X, DA AGO PRT-1441. The instructions were modified. Each item consists of a single key word, presented with no context, and four alternatives from which the subject chooses the word that means the same or about the same as the key word.

Test 62. Vocabulary

Raw Scores	-3 -1	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	27 29	30 32	33 35	36 38	39 41	42 44	45 47	Total
Frequency	2	8	21	24	27	31	19	19	13	13	9	4	3	1	3	1	2	200

63. Word-Group Naming is a new test in which the subject is to give a definitive name to a group of five words. It was intended to be a verbal counterpart of Picture-Group Naming (variable 42).

Write the best name for the list.

volcano
oven
Africa
fire
sun

____

Test 63. Word-Group Naming

Raw Scores	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	Total
Frequency	1	4	13	13	28	22	37	28	21	11	9	9	4	200

64. Word Selection is in part adapted from Test 3 of the Terman-McNemar Test of Mental Ability, Logical Selection (used with the permission of World Book Company). About half the items are new. Each item requires the subject to choose from a list of five words one that refers to something that is always involved in the referent of the key word.

Check what the thing always has or involves.

Winning always involves:

______ gambling
______ happiness
______ losing
______ money
______ cheating

Test 64. Word Selection

Raw Scores	-2 -1	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	Total
Frequency	2	2	17	17	12	23	32	19	31	14	14	13	4	200

65. Word Squares is an original test given in two parts. In part A, verbal matrices containing two rows of two words each are presented; two (or in one case only one) of the words are given and the other two (or three) words have to be selected from five alternatives so that the two words in each row will be related in the same way. Part B, which was administered with a separate time limit, is more complicated, involving matrices with three or four rows of three or four words each; eight or ten alternatives are given for filling in three or four blanks. In the scoring of the test, each blank to be filled in was regarded as an item to be scored right or wrong. It was originally thought that Parts A and B might be treated as separate variables. The high relation between them, however, led us to combine the two scores into one.

In each blank write the letter of the word which should go there.

arm ________

________ foot

A. hand
B. toe
C. glove
D. leg
E. walk

Test 65. Word Squares

Raw Scores	0 2	3 5	6 8	9 11	12 14	15 17	18 20	21 23	24 26	27 29	30 32	33 35	36 38	39 41	42 44	45 47	48 50	51 53	54 56	Total
Frequency	0	2	5	9	12	15	16	29	31	12	17	12	10	9	6	4	4	4	3	200

66. Education was simply the number of years of formal schooling.

Test 66. Education*

Raw Scores	6	7	8	9	10	11	12	13	14	Total
Frequency	6	20	29	37	48	17	38	2	3	200

*The raw scores for this variable represent years of academic education.

6. Tests Used to Establish Reference Vectors for Factors Other Than Reasoning

The reader may find it useful to have a summary of the tests included primarily to assist in identifying previously reported factors other than reasoning. Eighteen of the 66 variables were used to help identify nine such factors. It is ordinarily considered desirable to include two tests to identify a factor, and where possible the two selected should be tests that have had high loadings on the factor in previous studies.

The factors that it was thought useful to identify in this study were those previously originally isolated in studies primarily from Thurstone's laboratory, although the majority have been confirmed in studies originating elsewhere.

For the familiar Verbal factor we used Test 62, Vocabulary, and Test 49, Reading. Several others, especially Reading II, were expected to have loadings on the Verbal factor, but they were included for other reasons. For Word Fluency we used Test 17, First and Last Letters, and Test 55, Suffixes. To identify Ideational Fluency, we included Test 57. Things Round, and Test 58, Topics.

In an attempt to get at the early Perception (P) factor, in case it exists apart from Speed of Closure, we included Test 20, Identical Forms, and Test 29, Mutilated Pictures. For Speed of Closure, we used Test 54, Street Gestalt Completion, and Test 30, Mutilated Words. Test 4, Camouflaged Outlines, and Test 9, Designs, were used in the hope of identifying Flexibility of Closure.

For the Number factor, we used Test 33, Numerical Operations I, and Test 34, Numerical Operations II. These tests usually define a number factor unequivocally.

Thurstone's recent work reveals two types of space factors that it was thought desirable to attempt to separate.* For S_1, which Thurstone believes represents the ability to visualize a fixed configuration when it is rotated into different positions, we used Test 5, Cards, and Test 16, Figures. A second space factor, S_2, has been interpreted by Thurstone as the ability to visualize a configuration in which there is movement among the parts of the configuration. In the interests of helping to clarify such a factor, we included Test 27, Mechanical Movements, and Test 56, Surface Development. These four tests, as well as several of the others, were selected upon the advice of Professor Thurstone.

---

*Thurstone, L. L.. Mechanical aptitude III: Analysis of group tests. The Psychometric Laboratory, The University of Chicago, No. 55, May, 1949.

A number of previous factorial analyses have yielded a factor designated by some such term as "Mechanical Experience." The relation of this factor to the space domain has not been clear. It has been reported to have loadings for tests of mechanical information as well as for tests like Mechanical Movements. It was thought that the loading on the latter, Test 27 (included as a reference variable for S_2), together with the loading on Test 26, Mechanical Information, would help to throw some light on the question of the separate existence of or the relation between space factors and that called Mechanical Experience.

The remaining 46 tests were included in the study either because one or more earlier factorial analyses had raised the question of their relation to some type of reasoning or because some hypothesis suggested that they might reveal something of the nature of reasoning. The 66th variable was Education.

Chapter B

Collection of the Data

1. The Subjects

The final plan of the 66-variable study specified 200 subjects as representative as feasible of the enlisted men in the Army. The purpose of this requirement was to increase the applicability of the findings to the classification of Army men. In order to insure complete data on at least 200 men, 226 were included in the original test group. They were enlisted men from Companies E, F, and G of the Second Infantry Regiment, stationed at Fort Jackson, South Carolina, who took the tests during the week of January 16, 1950.

The men to be tested had already taken the Army Classification Battery and were so selected that the distribution of their scores on Aptitude Area I (based on Reading and Vocabulary, Arithmetic Reasoning, and Pattern Analysis) covered a wide range. The particular distribution used was specified by representatives of the Adjutant General's Office as that likely to be reasonably typical of the enlisted men's population in the following few years.* The subjects were thus so selected as to include approximately 9 per cent with Aptitude Area I scores below 80, 41 per cent with scores from 80 to 100, 41 per cent with scores from 100 to 120, and 9 per cent with scores of 120 or above.

As had been anticipated, a small number of men were unable, for one reason or another, to complete all the tests. A few others showed what may be regarded as ambiguous zero scores on one or more tests. By this is meant that their papers gave evidence of probable failure to understand the instructions. By the omission of individuals for whom data were incomplete or who apparently had not followed instructions in one or more tests, the sample on which the analysis was based was reduced to 200. The only variable for which any arbitrary values were supplied was Education, in which it was deemed appropriate to assign the mean number of years of Education to five men for whom this information was lacking in order to keep the sample size at 200. (Data on Education were not received by us until after the original group of 226 had been reduced to 200 as described above.)

The years of birth for the men ranged from 1927 to 1932, with about 75 per cent falling in 1931 and 1932. In view of the restriction of the age range, it was decided not to treat age as one of the variables to be analyzed.

---

*Since the men in the sample had all taken the Army Classification Ba tery, we agreed to obtain for the Adjutant General's Office, in addition to the data called for by our contract, the intercorrelations of the 10 subtest of this battery, their correlations with our other 66 variables, and the correlations of all the variables with scores on a criterion variable collected by that agency. Since these data have already been made available to the AGO and since their analysis does not constitute an integral part of this study, they are not reported herein.

Education was the one variable other than a paper-and-pencil test score that was included in the factor analysis. The range was from 6 to 14 years of school work completed and the mean close to 10 years. The distribution is given under number 66 in our detailed treatment of the variables in Part II, Chapter A.

In reaching the decision to use a sample of Army enlisted men, we entertained some doubts as to whether or not they would work at as high a level of motivation as would, say, a high-school or college group. From the standpoint of motivation alone, doubtless the latter kind of sample would have been preferable. This consideration was outweighed, however, by the interest of representatives of the Adjutant General's Office in having the sample as representative as possible of the population of enlisted men.

Various ways of attempting to maintain test-taking morale at a high level were discussed, such as the device sometimes used of informing the men that their test scores will become a part of their permanent record. Such schemes were finally discarded in favor of having the commanding general at the installation introduce the test program to the men with an interpretation of its purpose and significance in improving the assignment of men according to their patterns of abilities. This introduction, which was based on material we had suggested, was very effectively presented; and we believe that it did help to maintain morale. Nevertheless, it should be stated that the morale did not appear to be so good as would be desired. To what extent this affected the results of the analysis cannot be determined with any assurance, but the degree to which the tests behaved in accordance with expectations as based on previous experience with them gives us some assurance that low morale was not a serious matter.

2. Planning the Order of the Tests

As indicated before, the plan of administering the 65 tests called for not more than 15 hours of testing time, including time for instructions and rest periods, to be spread over five consecutive days. The tests were to be divided into five groups for the five days and each of these groups split into three subgroups no one of which would require more than an hour. In the final plan, the shortest session without a rest period was to take 39 minutes and the longest 58 minutes, exclusive of the time required for collecting and distributing the tests. As explained in connection with our description of variables 45-48, subtests B-E of Raven's Progressive Matrices test, however, the examiner found the men so restive after a number had finished the test that he called time at the end of 26 minutes instead of allowing ample time for all to finish.* Hence one session required only 29 minutes in all. Each session contained either four or five tests or subtests.

---

*Although in some respects this reduction in time may have been unfortunate, we later felt that it may have assisted in the interpretation of factor D'.

When as many as 65 tests are to be taken, careful plans must be made to minimize undue effects of boredom and fatigue. It was considered especially important to rotate tests presented in the same medium or seeming to call for the same kind of ability. In segregating the tests into days and sessions within the same day, we therefore separated similar tests as much as possible, considering both the kind of mental operation apparently called into play by each test and the medium in which the test was presented. Thus the different kinds of analogies tests were placed in different sessions, as were the different kinds of series tests, the different classification tests, the different puzzles tests, and so on. A similar separation was effected insofar as possible for the different tests based on geometrical patterns or symbols, meaningful objects, words, and numbers and for the reference tests for each of the previously isolated factors.

The final plan for the order of administration of the tests is given in Table 9 in Appendix II.

3. Administering and Proctoring the Tests

The senior author and representatives of the Adjutant General's Office made a preliminary visit to Fort Jackson to inspect the facilities for administering the tests and to complete the arrangments for selection of the subjects, the proctoring of the tests, and numerous other details. The personnel at Fort Jackson offered excellent cooperation so that the entire operation could be conducted in a very effective and orderly manner.

The tests were administered by Mr. Albert Branca, an advanced graduate student in psychology at the University of North Carolina, who has had considerable training and experience in the administration of tests as well as experience in dealing with Army men. He was provided with detailed instructions for administering each test.

Mr. Branca was assisted by 12 proctors provided by Fort Jackson, all of whom had had a year or more of experience in proctoring tests in the Army. This meant that there was one proctor for approximately every 20 subjects.

The tests were administered in one large room especially designed for testing. The work space for each man was separated from neighboring spaces by opaque partitions.

Each man was assigned a number before the sessions began, and all the copies of each test were serially numbered. A proctor was responsible for distributing and collecting the properly numbered copies of each test to the men in his section. No test booklets were lost or otherwise unaccounted for.

The large number of proctors and the arrangement of the room made it possible to collect and distribute tests in a highly efficient manner, so that not more than a minute or two elapsed between the tests in any

single session. Rest periods of from 10 to 15 minutes, during which the men were permitted to smoke or have a soft drink, followed each of the first two sessions each day.

The senior author was in the examining room during the entire first two days of testing, but there was no necessity for her to remain for the following three days since it was clear that no difficulties were likely to arise.

4. Scoring the Tests

As stated before, all the tests were prepared in hand-scoring form. In the interest of keeping the scores as factorially simple as possible, the tests were so designed that the answers would be recorded in as natural a manner as possible. The booklets were arranged for the convenience of the subject rather than for scoring ease. The only tests for which a separate answer sheet was necessary were the subtests of Raven's Progressive Matrices test (variables 45-48), which was used in the form developed by Raven. Thus in general the pages of the test were not cluttered with item numbers or with letters or numbers referring to the answers.

The tests were hand-scored with the use of either stencils or strip keys. All operations were checked by a second person and discrepancies resolved by a third.

5. Coding the Scores

The plan of the study was to transform the frequency distributions to approximately normal distributions and then base the factor analysis on product-moment correlations among the "normalized" variables. In the coding of the scores, our aim was to have for each variable scores of from 1 through 9 (to facilitate the use of International Business Machines computing equipment), with relative frequencies of 4, 7, 12, 17, 20, 17, 12, 7, and 4, respectively. These were arrived at by taking 1.75-2.25 as standard deviation limits for a coded score of 9, 1.25-1.75 as standard deviation limits for a coded score of 8, and so on, and obtaining the percentage for each coded score as the difference between the centile limits corresponding to the designated standard deviation limits in a normal distribution. The percentage of cases in categories 1 and 9 was increased by one to take account of the fact that about 1 per cent of the cases fall beyond a standard score of -2.5 or 2.5. The mean of this model distribution is 5 and the standard deviation very close to 2.

It was of course impossible in the case of most tests to set the limits of the raw-score intervals corresponding to the coded scores to yield exactly the set of frequencies at which we aimed. Thus the lowest group may have contained nearer to 5 than to 4 per cent of the cases, the next group 6 instead of 7, and so on. If there was doubt as to the coded scores to which it was best to assign certain raw scores, alternative

resulting frequency distributions were compared with the "model" by the chi-square technique, and the classification which yielded the smallest value of chi-square was adopted. The reader can judge the extent of the departures of the final distributions of coded scores from the model by inspection of Table 10 in Appendix II, which gives for each of the 66 variables the raw-score limits and the frequencies corresponding to the coded scores. It seems reasonable to suppose that the differences in the distributions had an unimportant effect upon our findings.

Once the translation table was decided upon for each test, a clerk coded the scores and a second one checked the coding. All coded scores on our 66 variables, the 10 Army Classification Battery subtests, and the criterion measure supplied by the Adjutant General's Office and the subject's identifying code number were copied onto a specially designed data sheet for each subject. The transcription was checked.

6. Computing the Correlation Coefficients

The data sheets were sent to the computing laboratory of the Institute of Statistics of the University of North Carolina, where the squares of the product-moment correlation coefficiants were computed and checked by means of International Business Machines equipment. The coefficients themselves were obtained and checked by computing the square roots twice independently by calculating machine.

The matrix of the Pearson *r*'s so obtained for our 66 variables was analyzed by the centroid method of factor analysis as described in the next chapter.

Chapter C

Analysis of the Data

The 66-variable intercorrelation matrix, which is reproduced below the main diagonal of Table 11, was factored by the complete centroid method, using the highest entry in an array as the communality estimate at each stage of the factoring. With a battery as large as this, the accuracy of the communality estimates is not a crucial matter. When fourteen factors had been extracted, it was estimated, by the application of several rule-of-thumb criteria, that the common-factor variance had been substantially exhausted. Two additional factors were removed, however, as assurance that every significant dimension in the common-factor space would be accounted for. The final residuals, which are displayed above the main diagonal in Table 11 and summarized in the form of a distribution in Table 13, have a mean (absolute) deviation from zero of .020 and a standard deviation of .025. Since the sampling error of a correlation coefficient of zero based upon 200 cases is approximately .071, it is concluded that the 16th-factor residuals are not significant.

The projections of the 66 test vectors upon the 16 orthogonal centroid reference vectors are listed in Table 12.

An oblique structure was found after approximately 30 rotations of the orthogonal reference frame. The projections of the test vectors upon the oblique reference vectors are listed in Table 14, and the transformation matrix which relates the initial orthogonal solution to the rotated oblique solution is presented in Table 15. The cosines of the oblique reference vectors are presented in Table 16.

The approach to simple structure was fairly good, as may be seen by the large number of zero or near-zero loadings in Table 14. Only in the case of one or two of the factors which are considered to be residuals was the departure from simple structure marked.

In attempting to interpret the factors, we ordinarily give most attention to the three or four tests with the highest loadings. The test lists for each factor, however, include all with loadings of .25 or higher, and upon occasion comments are made on tests with lower but possibly significant loadings.

In the interpretations of the nature of the factors and the relative merits of alternative hypotheses, not only what tests have high loadings but also the ones with clearly insignificant loadings are considered. To be completely satisfactory, a hypothesis should explain why certain tests have high and others low loadings.

Presented first are the loadings and interpretations of eight factors (C', D', J', K', L', N', O', P') considered to be outside the realm of reasoning. These are followed by discussion of five factors (A', B', F', H', M') that seem to be allied to reasoning. Finally, the loadings on three factors (E', G', I') regarded as residuals are given. The letter designations of the factors rotated in the 66-

variable study are differentiated by the use of a prime from those for the 38-variable study.

In the lists that follow, each loading that is the highest (or tied for highest) for the test in question has been indicated by an asterisk. Consideration of this feature of the loadings is in some cases of help in the interpretation of the factors.

Factor C' -- Verbal Relations

Test No.	Test Name	Loading
49	Reading	.51*
52	Sentence Order	.50*
62	Vocabulary	.41*
1	Absurdities	.40*
50	Reading II	.39*
44	Practical Situations	.36
40	Picture Arrangement	.29*
21	Incomplete Outlines	.25*
60	Verbal Classification I	.25

*Highest loading for the test.

Interpretation of Factor C' presents no difficulty, since it is clearly the Verbal factor found in many analyses by Thurstone and others. Seven of the nine tests in the list have their highest loading on this factor. All except 40, Picture Arrangement, obviously involve understanding of the meaning and relations of words or verbal concepts. Picture Arrangement, although presented in terms of pictures to be arranged in logical sequence and involving only a few words, apparently can be solved best by verbalization of the situations presented. It was anticipated that it might have a significant loading on the Verbal factor.

It is interesting that the new test, No. 52, Sentence Order, has almost as high a loading as No. 49, Reading, and a higher loading than No. 62, Vocabulary, and No. 50, Reading II. The difficulty of the vocabulary in the Sentence Order test is very low--much lower than the vocabulary difficulty of the two reading tests and the Vocabulary test itself. Picture Arrangement, it may be recalled, is similar to Sentence Order but involves minimal use of high-level vocabulary. The loadings of these two tests on the Verbal factor suggest that its interpretation should stress the perception and manipulation of verbal relations rather than merely the understanding of the meaning of words. The loadings of Absurdities (No. 1), Practical Situations (No. 44), and Incomplete Outlines (No. 21) bolster this interpretation. Their emphasis, like that of Sentence Order and Picture Arrangement, is on "making sense." It is therefore suggested that the name "Verbal Relations," used by Thurstone in his Primary Mental Abilities study, is

more descriptive of the factor than the term "Verbal Comprehension," which has gained wider usage.

Other investigators have sometimes found tests of arithmetic reasoning to have significant loadings on the Verbal factor. The explanation of the low loading (.02) of our arithmetic reasoning test probably lies in our attempt to reduce its vocabulary level and verbal complexity with the express purpose of decreasing its loading on the Verbal factor.

Factor D' -- Perceptual Speed

Test No.	Test Name	Loading
18	Forms	.43*
3	Block Counting	.37*
48	Progressive Matrices E	.32*
20	Identical Forms	.31
36	Overlapping Circles	.31
65	Word Squares	.27
4	Camouflaged Outlines	.26

Factor D' is more difficult to interpret than C'. We believe, however, that it is best described as a perceptual speed factor rather than as any sort of reasoning factor.

The Forms test requires that combinations of three supposedly meaningless forms or symbols be "evaluated" by the two rules: (1) If a symbol is followed by itself, the combination is equal to that symbol; (2) A combination of any two of the symbols is equal to the third symbol. This test has been used in only one previous study, that of Coombs.* With a time limit of five minutes, he found it to have a loading of .37 on a factor called "induction" that was not very strongly identified. Our study has yielded three factors that we interpret as related to induction; in other words, the factor that some other studies have more or less tentatively called Induction seems to have been broken down into three factors. The loading of .26 of Forms on one of these three, M', which we have called "Concept Formation," probably corresponds to Coombs' loading on his inductive factor. We increased the time limit to seven minutes but nevertheless got a severely positively skewed distribution. It may be noted that the nature of the problems is such that once the rules are understood, any subject can solve them correctly given sufficient time. Our examiner found that twelve minutes were required for the instructions in order that he could be reasonably sure that the task would be understood. This was much more than Coombs had allowed, so that it may well be that more of our subjects clearly understood the rules involved. This might explain why we found a loading on a speed factor, whereas Coombs did not. Since the Forms test clearly depends upon some sort of visual perceptual ability, the loading of Forms on Factor D' suggests that it is Perceptual Speed.

---

*Coombs, Clyde H. A factorial study of number ability. Psychometrika, 1941, 6, 161-189.

As for Block Counting, the form we used is identical with that of Thurstone,* except that he used a time limit of seven minutes while we used nine. In a later use of the same test, Thurstone increased the time limit to 10 minutes.** In his first analysis, Thurstone reported a loading of .41 on a space factor, .36 on a factor he called "restrictive task ability," and .37 and .35 on residual factors. In his study of mechanical ability,*** the highest loading of Block Counting was .20 on a factor identified as "flexibility of closure." Again it may be noted that once the task in Block Counting is understood, the problems themselves are not intrinsically difficult if sufficient time is available, and that again the test involves visual perception. It should also be mentioned that Block Counting had a loading of .26 on Factor E in our 38-variable study, which was interpreted as Perceptual Speed.

Perhaps the loading of Progressive Matrices E, .32, which is its highest loading, may help explain this factor. We had planned originally to allow 40 minutes for administering the Progressive Matrices test, and if necessary to extend the time to as much as 50 minutes so as to permit at least 90 per cent of the subjects to finish. (These time estimates were arrived at from the author's recommendation in the test manual and from our preliminary tryout with high-school students.) As noted above, however, our examiner found that the group became so restless when the majority had finished that he felt calling time at 26 minutes was essential to the preservation of morale. At that point 127, or 63 1/2 per cent, had finished the entire test; and 196, or 98 per cent, had finished Part D. This circumstance leads to several interesting considerations. In the first place, Parts B, C, and D more nearly approximate power tests (if we can ignore the 4 individuals who did not complete D), while E is a highly speeded test. This will become important in any interpretation of Factor B', on which Parts B, C, and D are highly loaded. In the second place, the variance-producing effects of differences in speed upon Parts B, C, and D will show up in the factorial picture of Part E, since the starting time for Part E, and hence the number of items completed in Part E, was a function of rate of working in the three preceding parts. We may expect, then, that the factor loadings for Progressive Matrices E are influenced by whatever ability or abilities determine speed of performance on Parts B, C, and D (and, of course, Part E itself) as well as by differences in whatever ability or abilities Part E may measure independently of the other sections. This loading of .32 for Progressive Matrices E, then, we interpret as the result of differences in perceptual speed as they operate throughout the entire Progressive Matrices test.

---

* Thurstone, L. L. Primary mental abilities. Psychometric Monographs, No. 1, 121 pp.

** Thurstone, Thelma Gwinn and Thurstone, L. L. Mechanical aptitude II: Description of group tests. The Psychometric Laboratory, The University of Chicago, No. 54, March, 1949.

*** Thurstone, L. L. Mechanical aptitude III: Analysis of group tests. The Psychometric Laboratory, The University of Chicago, No. 55, May, 1949.

Rimoldi's analysis of a set of variables including the Progressive Matrices subtests resulted in a loading of .29 for Part E on a factor interpreted as Speed of Perception, as well as a loading of .28 on this factor for Part D. (Progressive Matrices D had a loading of .17 on our Factor D'.) Rimoldi notes that the speed with which certain details are perceived seems to be important in Parts D and E, although this is difficult to interpret in the light of his statement that the Raven tests were administered with "no time limit."*

The loading of .31 for Identical Forms on Factor D' further confirms its interpretation as a perceptual speed factor. Although the factorial composition of this test is complex, a finding for which an explanation will be advanced later, perceptual ability might well be expected to contribute to its variance. It has had a significant loading on Thurstone's P (Perceptual Speed) factor in a number of his studies and those of others.

One of our reasons for including Test 29, Mutilated Pictures, in the battery was our thinking that it would help to establish the Perceptual Speed factor; but its loading on Factor D' is only .13. It may be noted that in the only other study in which, to our knowledge, it has been analyzed, Thurstone's mechanical aptitude study, no factor corresponding to Perceptual Speed was isolated.

The loading of .26 on Factor D' for Camouflaged Outlines is in good agreement with its loading of .30 on Factor E, Perceptual Speed, in our 38-variable study. It seems reasonable enough to find a perceptual speed factor contributing to performance on Overlapping Circles, and the loading of .27 for Word Squares may be attributed to the varying spatial patterns of the blanks for which appropriate fundaments have to be selected.

This perceptual speed factor seems to be distinct from speed of closure, which appears to describe our factor N'. Factor D' agrees pretty well with French's description of Perceptual Speed, in which he stresses the task of finding a given configuration in distracting material and the fact that the tests of this ability are all speeded.**

---

*Rimoldi, H. J. A. Study of some factors related to intelligence. Psychometrika, 1948, 13, 27-46.

** French, John W. The factorial composition of aptitude and achievement tests. Psychometric Monographs, No. 5, 1951. (Available in prepublication draft.)

Factor J' -- Number

Test No.	Test Name	Loading
34	Numerical Operations II	.58*
33	Numerical Operations I	.52*
32	Number Series	.38*
2	Arithmetic	.33*
37	Painted Blocks	.32*
6	Circles	.31*
22	Letter Series	.30*
23	Logical Puzzles	.25

Factor J' is readily identified as the familiar Number factor, which represents facility in handling numbers. For the first seven of the eight tests listed, the loading on J' is the highest loading. The numerical feature is obvious from the titles of the first four. Painted Blocks requires answering questions on numbers of blocks of specified characteristics resulting from cuts applied to larger blocks. The rules governing the placement of the blackened circles in Circles call for counting or understanding of numerical relations. All items in Letter Series can be solved by translating the relations between the letters into numerical terms, and it is likely that many subjects made such a translation for certain of the items.

In the construction of Logical Puzzles, we had attempted to exclude problems that seemed to require numerical ability and to include ones that depended on logical reasoning or the ability to draw inferences. Problems that called for numerical ability we attempted to segregate in the test called Numerical Puzzles, which apparently was too difficult for our group and which had a communality of only .23. The three problems involving numbers that were placed in Logical Puzzles possibly account for its loading of .25 on the Number factor. Factor J' in this study is the same as Factor C in our 38-variable study, although it may be noted that Painted Blocks had a loading of only .12 on Factor C.

Factor K' -- Word Fluency

Test No.	Test Name	Loading
55	Suffixes	.48*
17	First and Last Letters	.43*

The only loadings of .25 or more on Factor K' are on the two tests included to identify Word Fluency: Suffixes, and First and Last Letters. The Factor K' loadings for these two tests are their highest ones. Four other tests have loadings between .20 and .25 on Factor K': Word-Group Naming, Picture-Group Naming, Mutilated Words, and Vocabulary. This list contains the variables we should expect to find for Word Fluency,

or the ability to produce quickly words that fit certain more or less mechanical specifications, with little regard for the quality of the associations.

Factor L' -- Space 1

Test No.	Test Name	Loadings
16	Figures	.56*
5	Cards	.55*
3	Block Counting	.30
19	Geometrical Puzzles	.30*
56	Surface Development	.27*
25	Matrices VI	.26
58	Topics	.25

This factor has its highest loadings on Figures and Cards, the two tests included to identify or verify Thurstone's Space 1 factor, which seems to involve visualization of a rigid configuration when it is moved into different positions.* These are the two tests that had the highest loadings on Thurstone's Space 1 factor. All the tests in the list clearly involve some sort of spatial ability--even Topics, since the topic used was "A Man Going Up a Ladder." The loadings on this factor are the highest not only for Figures and Cards but also for Geometrical Puzzles, Surface Development, Paper Folding (.21 on this factor and Factor P') and Numerical Puzzles (.19).

It should be noted that the loadings of .30 for Block Counting and .27 for Surface Development are not consistent with Thurstone's loadings for these tests of -.03 and .05 on Space 1 in his mechanical study. For him, Block Counting had no loading greater than .20 and Surface Development had its highest loading on Space 2. (For our factor most like Space 2, P', Surface Development has a loading of .18, its second-highest loading.) Possibly the explanation for these differences lies in the fact that Thurstone's subjects were all enrolled in physics classes in a technical high school, whereas our subjects were not so selected.

It may also be pointed out that the agreement between the tests with lower but possibly significant loadings on this factor and Factor A, which we tentatively identified as Space 1 in our 38-variable study, is not very great. In that study, it will be recalled, we did not have available reference tests as satisfactory as for the larger study. Paper Folding, which has one of its highest loadings on Space 1 in this study, had a loading of .37 on Factor A in the smaller study. Planning a Circuit had a loading of .33 in the small study,

---

*Thurstone, L. L. Mechanical aptitude III: Analysis of group tests. The Psychometric Laboratory, The University of Chicago, No. 55, May, 1949.

.18 in the larger one. The greater discrepancies in the case of Block Counting (.13 vs. -.01), Decoding (.23 vs. -.03), Camouflaged Outlines (.25 vs. -.01), and Mechanical Principles (.25 vs. .00) may again be attributable to differences in the samples of individuals or the samples of tests for the two studies.

Factor N' -- Speed of Perceptual Closure

Test No.	Test Name	Loading
54	Street Gestalt Completion	.58*
20	Identical Forms	.48*
30	Mutilated Words	.43*
29	Mutilated Pictures	.42*
42	Picture-Group Naming	.28
4	Camouflaged Outlines	.26

The four tests with highest loadings on Factor N' are also the four highest tests on Thurstone's Speed of Closure factor in his study of mechanical aptitude. This is the ability to organize a chaotic visual field into a single percept. It had been thought that possibly the ability in question might transcend the visual modality, but there is no evidence in this study to support such a hypothesis. All the tests loaded on the factor involve perception. Perhaps the factor should be renamed "Speed of Perceptual Closure" to make this restriction specific, although the term "closure" originally connoted a visually perceived field.

Factor O' -- Ideational Fluency

Test No.	Test Name	Loading
58	Topics	.52*
57	Things Round	.46*
43	Reasons	.43*
24	Map Planning	.25
36	Overlapping Circles	.25

The tests for Factor O' include as the first two those used to identify Ideational Fluency. The third test, Reasons, was also expected to be heavily saturated with Ideational Fluency. Hence we interpret this factor as the ability to produce ideas rapidly, regardless of their quality.

It may be noted here that the Reasons test was included partly to test the hypothesis that fluency in producing ideas which are "reasons" may have a factorial composition which differs from that of fluency in other ideational activity. Our results for this test, however, do not support such a hypothesis, since the factor loadings for Reasons show no significant projection other than that for O'. It is interesting to speculate concerning the probable results from such a test if the responses were scored according to some criterion of goodness or

"reasonableness" rather than merely according to the number of responses. Questions such as those used in this test have been shown to be valuable measures of "general intelligence" (as, for example, in the Comprehension subtest of Wechsler's scale), and it is probable that the use of some well-selected "why" questions which call for the production of reasonable hypotheses rather than information may assist our understanding of reasoning.

That Map Planning, Overlapping Circles, Practical Situations, Decoding, Street Gestalt Completion, and Sentence Order have small but possibly significant loadings (from .20 to .25) on Ideational Fluency is not surprising.

Factor P' -- Space 2

Test No.	Test Name	Loading
26	Mechanical Information	.50*
27	Mechanical Movements	.41*
44	Practical Situations	.30
43	Planning a Circuit	.28*
62	Vocabulary	.27
8	Decoding	.25
49	Reading	.25

The identification of Factor P' is not so clear-cut as for most of the preceding ones. It will be noted first that, in the 38-variable study, the counterparts of the three tests with the highest loadings on this factor, Mechanical Information, Mechanical Movements, and Practical Judgment, had loadings of .51, .56, and .28, respectively, on Factor D (Visualization), the factor that was thought possibly to be the same as Thurstone's second space factor. In addition, in the smaller study, Planning a Circuit had a loading of .18 and Painted Blocks .37 on Factor D. The loading on D for Decoding was -.01, while those for Vocabulary and Reading were .10 and .18, respectively. On the whole, the agreement is reasonably satisfactory, especially for the two highest tests, which are counterparts of tests among the highest ones for Thurstone's second space factor, Space 2. Surface Development, with a loading of .37 on his Space 2, has a loading of .18 on our P' and .27 on our L', which more nearly corresponds to Thurstone's Space 1.

It may be recalled that our battery included Mechanical Movements and Surface Development to test the hypothesis that they would confirm Thurstone's second space factor. Mechanical Information was also included because of earlier findings that it, together with Mechanical Movements, was loaded on a factor interpreted as mechanical experience. Although Mechanical Movements and Mechanical Experience both have high loadings on Factor P', Surface Development does not have the high loading that we had predicted. Actually, its only loading above .18 is the one on L' (Space 1) mentioned above.

Thurstone interprets Space 2 as the ability to visualize a configuration in which there is movement or displacement among the parts of the configuration.* Since in our battery only the Mechanical Movements test clearly depends significantly on this type of ability, we have named the factor Space 2 only with some doubt. The fact that it has loadings of .25 and .27 on Reading and Vocabulary we find somewhat difficult to understand, even though the explanation may lie in the fact that Mechanical Information is presented wholly in verbal terms. By the same token, however, Mechanical Information might have been expected to have a similar loading on C', the Verbal factor, whereas actually its loading is .08. In any event, we do not feel that the hypothesis that the variance in the factor is accounted for by "mechanical experience" rather than a more fundamental ability of the type posited as Space 2 has been completely ruled out. We note, however, that the four highest tests in this factor are tests which deal with meaningful, "real" things (machines, wheels, etc.) or are tests which are easily influenced by specific experience (as the "electrical maze" items of Planning a Circuit). This circumstance is also true of the best "Space 2" tests of Thurstone as well as the tests considered by the Air Force writers as measures of "Mechanical Experience." Thurstone's "Space 2" would be better established, we feel, if the kind of visualization involved were shown in tests of non-meaningful or more or less abstract stimulus items.

We turn now to a consideration of the five of our factors that appear to be most closely allied to the realm of reasoning, A', B', F', H', and M'.

Factor A' -- Perception of Abstract Similarities

Test No.	Test Name	Loading
61	Verbal Classification II	.52*
60	Verbal Classification I	.43*
11	Figure Analogies	.34*
65	Word Squares	.34*
12	Figure Classification I	.29
39	Picture Analogies	.29
7	Conclusions	.26*
8	Decoding	.25

Of the four tests highest in the list for Factor A', the first two are verbal classification tests and the other two may be regarded as analogies tests, since Word Squares requires selection of words to complete analogies. In addition, it may be noted that the loadings on this factor for Picture Analogies and Figure Classification I are their highest (except for loadings on residual factors). The findings for these six tests, together with a loading of .21 for Verbal Analogies, establish that this factor is concerned with some type of ability

---

*Thurstone, L. L. Ibid.

common to certain classification tests and to analogies tests regardless of their medium.

Let us introspect about the task in Verbal Classification I and II. The subject must first perceive the meaning of the words in each of the two lists that define the classes and in the list of words to be assigned to one or the other of the classes. Although an attempt was made to keep the vocabulary level low, the loadings of .25 and .20 on the Verbal Relations factor, C', are not surprising. Then the subject must discover the ways in which the words within each of the two defining lists are alike. In doing this, he must perceive not just any way in which the words within each list are alike but must discover a basis for their likeness that differentiates them from the words in the other list. Thus he must perceive and perhaps verbalize the relation between the two bases or principles for classifying the words. He may have to think of and test out different bases of classification before he finds the way to differentiate the two lists. Once he understands the principle of classification, he assigns the test words to one or the other of the two classes. Verbal Classification II, based on principles more difficult to recognize than those in Verbal Classification I, has the higher loading on the factor.

In the analogies items, vocabulary difficulty seems minimal--thus one finds in Verbal Analogies such words as "boat," "man," "ring," "learn," "dog," and "apple." None of the analogies tests had significant loadings on the Verbal Relations factor, C'. Once the meaning of the words or objects is perceived, the subject must see and will usually verbalize the relation between the first and second members of the analogy, which ordinarily involves some difference between them rather than a way in which they are alike. Then he must select from among, say, five elements one related to the third (given) member of the analogy in the same way that the second is related to the first. Thus he must, so to speak, recognize or produce two relations that are the same or sufficiently similar to be regarded as the same. Here, too, he may try out different hypotheses, since the items are presented in multiple-choice form. For he may think of a relation between the first two elements which none of the alternatives will satisfy with the third. This would be rather rare for the analogies tests that we used.

Figure Classification I was based upon an Air Force test in which each item presents three rather simple figures to define a class and the subject selects the one of five additional figures that is like the first three. Here the subject first finds and probably usually verbalizes the way in which the first three figures are alike. Once he sees the basis of similarity, finding the fourth figure that is like the first three should be relatively easy. In only a very few items would the subject find that no test figure would satisfy the principle of similarity he had perceived so that he would be forced to look for another way in which the figures are alike. Thus the emphasis on testing different hypotheses seems small.

It is suggested that the element that most clearly ties these three sets of tests together is perceiving abstract similarities. In the Verbal Classification tests, similarities between the referents of words are perceived. In Figure Classification I, principles of similarity among the figures presented must be found. In the various kinds of analogies tests, the similarities between the relations of the members of the two pairs constituting the correct analogies must be appreciated. The type of similarity involved in this factor is not simple identity of visually perceived detail like that which apparently loads a test highly on the visual perception factor, commonly denoted P. It is rather a type of similarity more important in abstract thinking. It perhaps might be described as educing relations of similarity.

Although Figure Classification I has its highest loading on this factor (except for its loading on a residual factor), Figure Classification IIA and Figure Classification IIB have insignificant loadings on it and very high loadings on Factor F', to be discussed below. Figure Classification II presents several sets of problems each based on two sets of three figures each to define two classes; the subject assigns test figures to one or the other of the classes. Figure Classification IIB is like IIA except that each set of items is based on three sets of three figures each and the subject assigns test figures to one of the three sets. The figures in these tests are much more complicated than those in Figure Classification I. In order to differentiate the classes the subject must perceive the relations between parts of the individual diagrams, bringing to mind various hypotheses and quickly rejecting those that do not work. This quality of flexibility apparently outweighs the importance of educing relations of similarity in producing the variance on these tests.

In previous investigations, we have encountered only one hypothesis that is at all similar to the one advanced here. Rimoldi has found a factor that he believes is concerned with the relation of likeness and its opposite.* His factor was loaded on Inventive Synonyms (.68), Group of Figures (.59), Inventive Opposites (.32), and Letters Series (.27). It was not significantly loaded, however, on Group of Letters (.06) or on Number Series (.15), for which no explanation was offered. Like our Factor A', Rimoldi's factor was not loaded on Classification of Figures (corresponding to our Figure Classification II), which in his study as in ours was loaded principally on a single factor. Rimoldi does not speculate on the reason for this finding.

It will be noted that Conclusions has its highest loading on Factor A'. Although we could attempt to rationalize this finding, the fact that for our sample the distribution of scores (corrected for guessing) is very similar to a distribution of chance scores, with a mode of -1, leads us to doubt the necessity of attempting to explain this one loading. The communality of Conclusions is only

---

*Rimoldi, H. J. A. The central intellective factor. Psychometrika, 1951, 16, 75-101.

.28, which is further evidence of its low common-factor variance.

In Decoding, the role played by perception of similarities is obvious.

In our interpretation of Factor B', which follows, we suggest that three of our factors, A', B', and M', all have some resemblances to the factor that others have interpreted as inductive. At this point, it may be desirable to note briefly previous reports on the factorial composition of the key tests. Verbal Classification, in one of Thurstone's early studies that used orthogonal rotation, had its highest loadings on Perception (P) and Space (S), and loadings in the neighborhood of .25 to .30 on the Verbal factor and on those interpreted as Inductive, Restrictive Task Ability, and Deductive.** As indicated in the description of our modification of the test format in Chapter A of Part II, we were attempting to reduce especially the loadings on Thurstone's P and S factors, and the results show that we apparently succeeded. Regarding the other factors, it is suggested that the inductive factor has been broken down into three factors, on one of which (A') Verbal Classification I and II are highly loaded. Although we also identify one of our factors as deductive reasoning, our Verbal Classification variables are not loaded on it; and we found no factor resembling the restrictive task ability, which Thurstone himself has regarded as a very tentative identification.

Figure Analogies and Verbal Analogies have both been reported by various investigators to have loadings on deductive and occasionally inductive as well as verbal and spatial factors. We also find them to have rather small but possibly significant loadings on the factor we interpret as Deduction and on one or more of the three factors that we believe to be allied to induction.

It might be argued that various kinds of series tests should show loadings on a factor involving the relation of likeness, as indeed Rimoldi reported for his Factor D, on which Letter Series was loaded. Our test 22, Series, is an adaptation of the series items in Cattell's Culture-Free Test, which are based on figures which progress or change according to some rule. It does have a loading of .22 on this factor. The other series test loadings ranged from .08 to .17, and all of these had higher loadings on one or both of the other factors, B' and M', that we believe to have been separated from the inductive factor as originally isolated. Although the subject must perceive the similarity of the relations between successive pairs of elements in a series for some items, apparently other aspects of the inductive process or other types of relationships involved in it are more significant for series tests in general.

**Thurstone, L. L. Primary mental abilities. Psychometric Monographs, No. 1, 121 pp.

Factor B' -- Hypothesis Verification

Test No.	Test Name	Loading
46	Progressive Matrices C	.57*
47	Progressive Matrices D	.54*
45	Progressive Matrices B	.47*
44	Practical Situations	.39*
48	Progressive Matrices E	.32*
59	Verbal Analogies	.32
10	False Premises	.30
53	Series	.29*
23	Logical Puzzles	.28*
32	Number Series	.27
64	Word Selection	.27*
14	Figure Classification IIB	.26

All of the subtests of the Raven Progressive Matrices Test have their highest loadings on Factor B', with those for subtests B, C, and D being considerably higher than that for E. It will be recalled that our discussion of Factor D', Perceptual Speed, pointed out that the time on the total Progressive Matrices test had been cut short, so that subtest E became much more of a speed test than had been intended. Subtests B, C, and D, on the other hand, would be expected to have their highest loadings on factors not placing a premium on speed. It seems reasonable, then, to regard B' as some sort of "power" factor rather than a "speed" factor.

Matrices VI, the British Air Ministry Test that has been said to be a good measure of Spearman's "g," has a loading of .23 on this factor but slightly higher loadings on two other factors yet to be interpreted, F' and M'. Among the several series tests, Series has its highest loading on this factor; Number Series has a loading of .27, Mixed Series .22, Figure Series .18, and Letter Series .16. These loadings on series tests, although not very high, when considered with those for the matrix tests rather strongly suggest that Factor B' represents some aspect of what is often referred to as inductive ability.

In another study that included all five of the Raven subtests as separate variables, Rimoldi found that all had significant loadings on one factor, while each also had loadings on various other factors.* Thus he reported the following loadings on one factor: Raven D, .68; C, .55; B, .54; E, .45; A, .34. Although our loadings for the four subtests that we used are in the order C D B E instead of D C B E, the disparity is not marked. Rimoldi interpreted his factor as inductive in character, although he had too few additional tests in his battery to confirm the interpretation. As a matter of fact, it may be noted here that the several subtests of Progressive Matrices

---

*Rimoldi, H. J. A. Study of some factors related to intelligence. _Psychometrika_, 1948, _13_, 27-46.

are not merely alternate forms of the same test. They differ discernibly in type of item as well as in difficulty. (The reader may wish to refer to the description of the variables in Chapter A for elaboration of this point.) For this reason, as well as because both Rimoldi and we have found the factorial composition of the various subtests to differ, we feel confident that we have here a genuine "factor" rather than a "quadruplet."

Rimoldi has pointed out that both Raven and Spearman considered Progressive Matrices to be saturated in "g." Interestingly enough, the Thurstones have stated that the tests Spearman designed as the best measures of "g" seem to be inductive in character.* Spearman has regarded "g" as a combination of noegenesis (the eduction of relations and correlates) and abstraction, and has claimed that an analytic approach to noegenesis tends to load the process with "g." Bernyer, however, has claimed to find the Progressive Matrices test (total score) loaded on an inductive factor in addition to "g."**

The principal characteristic of tests ordinarily considered to be inductive has been thought to be that they require the subject to discover a rule or principle. This description seems to fit the matrix and series tests but is not so clearly applicable to some of the others in the list. It should be noted at this point that both Factor A', referred to as "Perception of Abstract Similarities," and Factor M', later to be described under the term "Concept Formation," also appear to be related to inductive ability. Although our Factor B' is perhaps more closely similar to the factor that has been termed "Induction" by other investigators, it will be noted that all three factor lists contain some tests that previously have been reported as loaded on an inductive factor. This fact suggests that perhaps Factor B', as well as Factor A' and Factor M', deals with some particular aspect of induction.

One suggestion for describing Factor B' more precisely than merely as "induction" arises from the lower loading for Letter Series than for the other series tests and the lower loading of Matrices VI than for the Progressive Matrices subtests. In the case of each of these comparisons, the lower loading is associated with a completion test in which no alternative answers are presented. The hunch that we derive from this comparison is that in the tests with higher loadings, some of the subjects approach the problems by checking hypotheses that are suggested to them by the alternative answers. Thus the ability underlying Factor B' may be associated with the ability to verify hypotheses rather than the ability to "see" or "educe" rules or principles as such. Factors A'and M' appear to have more direct bearing on the latter kind of ability.

---

*Thurstone, L. L. and Thurstone, Thelma Gwinn. Factorial studies of intelligence. Psychometric Monographs, No. 2. 1941, p. 23.

**Bernyer, G. Analyse factorielle de tests d'aptitude technique. L'Année Psychologique, 1946-47, 198-207.

It may also be noted that Word Squares has a loading of only .03 on B', as contrasted with the loading of .32 for Verbal Analogies. In Word Squares, which is also a type of analogies test, different fundaments are missing for different items, and at least two must be supplied for each. It is true that they are to be selected from among the given alternatives, but the hypotheses as to the nature and similarity of the relationships involved seem much less obvious than in the case of Verbal Analogies. Although these comparisons are by no means conclusive, they at least suggest that perhaps the emphasis in the interpretation of Factor B' should be upon testing hypotheses, or what the logicians refer to as "empirical verification," rather than upon their formulation.

This notion fits in nicely with the tentative interpretations of Factor A' and Factor M'. Factor A', referred to as Perception of Abstract Similarities, has its highest loadings on the two Verbal Classification tests. Factor M', called Concept Formation, has its highest loadings on Picture-Group Naming, Word-Group Naming, and Verbal Analogies. Both of these factors have to do with what might be called induction of rules or principles or relations and hence might also be regarded as inductive. Our results suggest, then, that there are at least three factors that have to do with different aspects of inductive reasoning processes.

Although we are suggesting that our Factor B' is not parallel to Thurstone's inductive factor, it may be noted that the loading of Verbal Analogies on an inductive ability is not without precedent. In one study Thurstone reported it to have a loading of .32 on a factor he interpreted as Induction.* In other studies he has found an apparently different factorial composition. Perhaps differences in the samples at least partially account for the different factorial pictures. The study referred to above was based on a sample of seniors in a technical high school, whose verbal ability probably is below that of the more typical college sample. In our study, too, the verbal ability of the subjects is doubtless below that of the average 10th-grader For such subjects, differences in the ability to verify the different hypotheses suggested by the alternative answers for the Verbal Analogies items may contribute to the variance of the scores on this test.

We were at first surprised to find the highest loading for Practical Situations on a factor that seemed to be inductive in character. But when the factor is interpreted as the ability to test hypotheses rather than the ability to educe rules or principles, the difficulty disappears, for the subject must compare several alternatives and thus check the different hypotheses involved in reaching the solutions to the problem. Practical Situations also has a loading of .36 on the Verbal factor (C'), which is consistent with other reports. It has a loading of .30 on Factor P', which is heavily saturated with our mechanical tests; this loading is doubtless attributable to the

---

*Thurstone, L. L. The perceptual factor. Psychometrika, 1938, 3, 1-17.

nature of the items, even though an attempt was made to rule out items that clearly required mechanical information. It has a loading of .24 on Factor O', Ideational Fluency, which again is not difficult to understand.

Although we believe that the loading of Practical Situations on Factor B' is reasonable, other investigators have not reported similar loadings of so-called "practical judgment" or "common-sense judgment" tests on an inductive factor. Let us briefly examine previous findings for two of the Air Force batteries referred to as Foresight and Planning Tests.* In the first of these, a factor named Judgment was identified by its loadings on three tests: the first, called Mechanical Judgment, consisted of 28 "mechanical" items selected from a test called Practical Judgment, CI301BX1; the second, Non-Mechanical Judgment, contained the remaining 52 items from the Practical Judgment Test; and the third was Sequence of Maneuvers, CI410A, which presented diagrams of a series of five maneuvers and required the subject to plan the altitude between maneuvers to minimize climbing and diving. The second battery identified a factor called Judgment from two Practical Judgment tests, one of which involved items of the work-planning type; Competitive Planning, based on the completion-of-squares game; and Part I of Practical Estimations (CI308AX1), in which the task was to estimate which one of five activities would require the most or the least time. It has occurred to us that Hypothesis Verification might actually constitute a better description of what these tests have in common than does Judgment. Interestingly enough, in neither study were there included any of the tests that previously have been considered to be inductive in character nor was any other factor isolated in the two studies regarded as induction. We suggest, therefore, that the Air Force Judgment factor is allied to our Factor B'.

As far as we can ascertain, False Premises has been included in only two factor analyses, one by Thurstone** and a more recent one by Botzum.*** In Thurstone's early study, which involved an orthogonal rotation, False Premises had a loading of .19 on his Inductive factor, a loading of .36 on his tentatively identified Restrictive Task Ability, and the highest loading of any test on his Deductive factor, .58. Botzum, using oblique rotation, found a significant loading, .42, only on the factor he called Deduction, and again it was the highest loading for this factor. In our study its highest loading is .45 for Factor H', which we interpret as Deduction; and for us, too, this is the highest loading for the factor. For both the Thurstone and

---

*Guilford, J. P. (Ed.) Printed classification tests. Army Air Forces Aviation Psychology Program, Report No. 5, pp. 180-190.

**Thurstone, L. L. Primary mental abilities. Psychometric Monographs, No. 1, 121 pp.

***Botzum, W. A. A factorial study of reasoning and closure factors. To be published in Psychometrika.

Botzum studies the subjects were college students, while ours were not in general college aspirants. Perhaps this difference is sufficient to account for the fact that False Premises has a loading on our Factor B' as well as on Deduction.

The loadings on Factor B' for Logical Puzzles and Word Selection, while relatively low, are the highest loadings for these tests, both of which may well involve the ability to check hypotheses. Although the two Figure Classification II tests have most of their variance on Factor F', the loading on Factor B' of .26 for the more difficult part, IIB, is not unreasonable. Thurstone reported a loading of .41 on Induction for his Figure Classification test in his Primary Mental Abilities study. If it is assumed that this loading is attributable to the more difficult items and that our Factor B' is a part of his more complex inductive factor, then our finding is reasonably consistent with his, particularly when it is remembered that loadings on factors that are positively correlated are higher for orthogonal than for oblique rotations to simple structure.

Factor F' -- Flexibility of Perceptual Closure

Test No.	Test Name	Loading
13	Figure Classification IIA	.50*
14	Figure Classification IIB	.44*
24	Map Planning	.42*
4	Camouflaged Outlines	.37*
20	Identical Forms	.31
19	Geometrical Puzzles	.28
6	Circles	.26
8	Decoding	.26*
36	Overlapping Circles	.25

Factor F' has been one of the most puzzling to interpret. It does not correspond fully with any previously identified factor, and several of the tests in its list are factorially complex. We have carefully considered the tests that are and those that are not in the list; we have also reviewed their factorial composition in this study and that of the same or similar tests in other analyses; and we have examined the lists of tests reported for different factors described in terms of hypotheses that were thought possibly to be applicable to our list. After a fairly exhaustive inquiry, we believe that the best description of the factor is in terms of flexibility of perceptual closure or closure against distracting material. Thurstone*

---

*Thurstone, L. L. Mechanical aptitude III: Analysis of group tests. The Psychometric Laboratory, The University of Chicago, Report No. 35, May, 1949.

Thurstone, L. L. A factorial study of perception. Psychometric Monographs, No. 4, 1944.

has termed one of the factors in his perceptual and mechanical aptitude studies "flexibility of closure," and one of Botzum's* factors agrees fairly well with it. As Botzum notes, Rimoldi** and Yela*** have found somewhat similar factors.

In Thurstone's perceptual study, he described a flexibility of closure factor in terms of the manipulation of two configurations simultaneously or in succession, stressing the ability to shake off one set in order to take on a new one. He stated that "freedom from Gestaltbindung might be an appropriate description in that it implies flexibility in manipulating several more or less irrelevant or conflicting gestalts." He found Two-Hand Coordination, Hidden Pictures, Gottschaldt Figures, and the Primary Mental Abilities Reasoning composite loaded on the factor. In his mechanical study, the factor interpreted as flexibility of closure or the ability to retain a configuration against distraction had its highest loading, .38, for Designs, a loading of .36 for Copying, .32 for Paper Puzzles, .30 for Gottschaldt Figures, and .26 for Surface Development. Botzum's flexibility of closure had a loading of .45 for Copying, .41 for Gottschaldt Figures, .38 for Designs, .29 for Block Counting, and .27 for Paper Puzzles. Thus the two factors were in pretty close agreement. Botzum's study included Thurstone's Figure Classification test and found it loaded only on Deduction and Space.

We shall recount some of the argument that led us to our interpretation of this factor. Let us note first that the highest loadings are for Figure Classification IIA and IIB, with the higher of the two loadings on the easier part. This type of figure classification test has been analyzed, so far as we know, only in two studies: the first was Thurstone's Primary Mental Abilities study, where he reported loadings of .41 on Induction, .40 on Deduction, .39 on Space, and .27 on a residual factor, using orthogonal rotation. No factor resembling flexibility of closure was found. The second was Botzum's study, where he used Figure Classification and did not find it to be loaded on his flexibility of closure factor. Thurstone's later description of the factor, "the ability to keep in mind a configuration against distraction, ... strength of closure...." does not seem to fit the Figure Classification tests as well as the original term "flexibility of closure." One significant characteristic of the Figure Classification tests would seem to be flexibility in structuring the visual field in different ways and yet the ability to retain certain configurations long enough to test the hypothesis involved. Perhaps the

---

*Botzum, W. A. Op. cit.

**Rimoldi, H. J. A. Study of some factors related to intelligence. Psychometrika, 1948, 13, 27-47.

***Yela, Mariano. Application of the concept of simple structure to Alexander's data. Psychometrika, 1949, 14, 121-135.

tests require more of such an ability among younger subjects than among older ones. Or possibly the explanation for our finding lies in the low level of verbal ability of our subjects. If they have difficulty in expressing verbal concepts, they may be forced to resort to perceptual processes in shifting from one hypothesis to another. Moreover, they could evoke such an ability more readily for the easier items in Part A than for the more difficult ones in Part B.

Factor F' is the one for which Map Planning has its highest loading. In the one study in which a similar test was analyzed by Air Force investigators,* Map Planning was reported to have (orthogonal) loadings of .45 on Perceptual Speed, .31 on General Reasoning, .28 on Visualization, and .27 on Spatial Relations. No flexibility of closure factor was found. We redesigned and redrafted the test in an effort to simplify its factorial structure. Our form of the test has a loading of .42 on Factor F', .25 on O' (Ideational Fluency), .23 on N' (Speed of Closure), and .20 on J' (Number), all other loadings being below .20. We have examined Air Force loadings for the other two Air Force tests in the list for Factor F', Camouflaged Outlines and Decoding, to see whether there was any Air Force factor common to all three that would suggest a good hypothesis for our Factor F'. Both Camouflaged Outlines and Decoding also have loadings above .25 on Perceptual Speed; only the former has a loading above .25 on Visualization. It has loadings of .21 and .27 on General Reasoning (I) in two studies, and Decoding a loading of .36 on General Reasoning. Although it might be argued that these findings mean that General Reasoning is the common element among all three, there is a stronger case, it would seem, for the point of view that it is some sort of perceptual factor that is involved. Besides, General Reasoning is the factor said to be best identified usually by Arithmetic Reasoning, which is not loaded on our Factor F'. Hence without any substantiating evidence from other sources, we suggest that the important element in Map Planning is allied to flexibility of perceptual closure.

Gottschaldt Figures has been regarded as one of the identifying tests for Flexibility of Closure. The form we used, called Camouflaged Outlines, is an adaptation of an Air Force test that is not exactly like the Thurstone-type Gottschaldt Figures test as used in his mechanical aptitude study. In the latter, each item presents one key outline which is imbedded in a more complex drawing. The subject finds the key figure as part of the larger and more complex drawing. In Camouflaged Outlines, five key figures are repeated at the top of every page. The subject indicates which of the five key figures is embedded in each of a number of more complex drawings.

---

*Guilford, J. P. (Ed.) Printed classification tests. Army Air Forces Aviation Psychology Program, Report No. 5, pp. 180-190.

Possibly this difference in presentation would affect the factorial composition somewhat. In any case, however, Camouflaged Outlines did have its highest loading on the factor that we are tentatively interpreting as Flexibility of Perceptual Closure.

The Identical Forms test has revealed an interesting although not unanticipated complexity of factorial composition. It would seem at first thought that it should be a simple test of speed of perception. It has its highest loading, .48, on Factor N', Speed of Perceptual Closure. (In Thurstone's mechanical aptitude study, it also had its highest loading, .27, on Speed of Closure.) In addition, it has loadings of .31 on three factors: D' (Perceptual Speed), H' (Deduction), and F'; and a loading of .26 on E' (a residual). Upon inspecting the test, we discovered that many of the items could be answered without looking at the key picture or form at all. What apparently happened in the construction of the test is that the artist drew a reasonably complete and esthetically pleasing picture as the key figure and then made variations on it as the distracters. Many of the distracters can be detected readily as missing some essential part or as being less pleasing than the others. To explore the matter further, we asked four college students to respond to the items without seeing the key figures, simply indicating the figures they thought would be the answers. Their scores of 30, 28, 19, and 18 right out of a total of 60 five-choice items indicate that factors beyond simple visual perception of identical figures may be expected to play a role in determining the variance on the test. That one such factor should be Flexibility of Perceptual Closure seems reasonable.

All the other tests with loadings of .25 or above on this factor, Geometrical Puzzles, Circles, Decoding, and Overlapping Circles, also involve some sort of visual perception and can reasonably be conceived to require flexibility of closure.

The Designs test was included in our battery as one of the reference tests for Flexibility of Closure, along with Camouflaged Outlines. Thurstone in his mechanical aptitude study found a loading of .38 for Designs on his second closure factor, as did Botzum in his recent study. Yet on our Factor F' Designs has a loading of only .08.

In the Designs test the subject is shown a model figure resembling an upper-case Greek sigma. The test consists of 30 rows of 10 more complex figures each, and the subject marks the ones in which the model forms part of the design or is embedded in it. The model occurs in only 40 of the 300 figures, and the test is highly speeded. The subject is to mark with an "X" the figures in which the model occurs and make no mark for the majority in which it does not occur. Thurstone has scored the test simply by counting the number of items marked which are right. This procedure does not directly penalize for either errors of omission or errors of commission (that is, the marks that are made for figures that do not contain the model). Since we noted that

a number of our subjects made errors of both kinds, we thought to improve the scoring by counting the total number of figures marked correctly and those correctly left with no mark, and subtracting the total number of figures marked incorrectly or incorrectly left with no mark. Although, as we anticipated, this scoring did effectively penalize subjects who tended to mark figures uncritically, the resulting scores correlated with the scores computed by Thurstone's method to the extent of .95. Although the correlation between the two sets of scores is very high, a number of subjects clearly depart from the trend of the regression. It is likely that for these individuals the test was approached with a different set, which one method of scoring tended to reward as compared with the other. Perhaps it should be pointed out explicitly that the factorial composition of two very highly correlated tests still may differ significantly in one or more dimensions.

It should be pointed out that the responses given on the Designs test by some of our subjects seem to indicate that they were not seeking just the figures containing the exact model but in some cases figures containing merely an outline of roughly the same shape as sigma. In other cases it is suspected that they sought a sigma no matter what its rotational position, despite the fact that the directions stated that the position of the model was always to be the same. The Figures test was administered on the first day of testing, Cards on the second day, and Designs on the third. Perhaps a carry-over of the set for the two space tests distorted results for Designs.

We have compared this factor with the one reluctantly referred to as "nonverbal, nonnumerical reasoning' (Factor G) in our 38-variable study. The resemblance is not close, especially when it is recalled that the type of Figure Classification test that was high on that factor is like our Figure Classification I rather than our Figure Classification II. For several other tests as well the agreement is not at all close.

One other idea will be explored. Guilford and his associates have set forth a number of hypotheses to be investigated in connection with a factor study of reasoning abilities.* It was noted that a Gottschaldt-figure test had been found to have some variance in R_{II} in the Air Force results. In considering what this test has in common with figure-matrix tests (which clearly are not loaded on our Factor F', however), they suggested the hypothesis that R_{II} or induction involves a form-analysis ability of some kind, assuming that a figure matrix is a complex form to be analyzed. This hypothesis was advanced as a possibility to be considered in accounting for the Air Force's R_{II}

---

*Guilford, J. P.; Comrey, A. L.; Green, R. F.; and Christiansen, P. R. A factor-analytic study of reasoning abilities: I. Hypotheses and descriptions of tests. Reports from the Psychological Laboratory. The University of Southern California, No. 1. June, 1950.

factor, which they believe to be inductive in character. It was suggested that perhaps Thurstone's flexibility of closure as found in his Gottschaldt Figures test is common to both perceptual and symbolic material. Without further ado, however, we may point out that while all of the tests loaded on our Factor F' involve forms of some kind, so do several of our other tests that are not loaded on the factor. And, in particular, none of our matrix variables appear on the list.

Hence we return to the hypothesis that F' represents Flexibility of Perceptual Closure as our best hunch as to its nature, even though the interpretation is not so clear in several respects as might be desired.

Factor H' -- Deduction

Test No.	Test Name	Loading
10	False Premises	.45*
20	Identical Forms	.31*
65	Word Squares	.30
59	Verbal Analogies	.26

The high loading of False Premises on this factor suggests that it is Deduction. In Thurstone's Primary Mental Abilities study, the factor that he tentatively identified as Deduction had its highest loading on False Premises. Identical Forms had a loading of .29 on his factor. Strangely enough, Verbal Analogies was not loaded on any reasoning factor, although three (Deduction, Induction, and Restrictive Task Ability) were tentatively identified. Rather, it had its highest loading on the Verbal factor (.60), a loading of .42 on Perception, and .31 on a residual. Perhaps the use of orthogonal rotation or the vocabulary level of the test accounts for these results.

Botzum's study also resulted in a Deduction factor, again with its highest loading, .42, for False Premises. He included two Verbal Analogies tests, one similar to our Verbal Analogies test and the other somewhat like our Word Squares test in that it required selection of both elements of the second pairs of the analogies. These tests had loadings of .26 and .24, which correspond to our loadings of .26 and .30. Both his factor and Thurstone's had loadings in the neighborhood of .40 for Figure Classification, whereas for our subjects the major share of the variance of Figure Classification IIA and IIB was accounted for by Factor F'. The only explanation we can offer hinges on differences in the subjects and possibly differences in the test batteries.

It was expected that Conclusions would also have a significant loading on a deductive factor. As noted earlier, however, this test proved too difficult for our subjects, with the result that the score distribution approximates chance.

Although the number of tests loaded on this factor is rather small, the extent of agreement with previous findings lends support to its interpretation as Deduction, which we would describe as the ability to draw correct inferences.

Factor M' -- Concept Formation

Test No.	Test Name	Loading
42	Picture-Group Naming	.44*
59	Verbal Analogies	.33*
63	Word-Group Naming	.33*
2	Arithmetic	.29
25	Matrices VI	.29*
48	Progressive Matrices E	.28
18	Forms	.26
22	Letter Series	.26
27	Mechanical Movements	.25

Four tests have their highest loadings on Factor M'. Of these, two are new tests requiring the subject to assign to a group of objects pictured or named the name of the narrowest category that will subsume all the objects. Thus for a group of men's hats, the names "clothing," "men's clothing," and "hats" would not be acceptable; only a designation conveying the narrower concept of "men's hats" would be scored as correct. These tests have no counterparts that have been analyzed factorially, so far as we know. Picture-Group Naming has a loading of .28 on Factor N' (Speed of Closure) and .20 on Factor K' (Word Fluency), both of which appear reasonable. Word-Group Naming is also loaded on Word Fluency to the extent of .24 and on Factor D' (Perceptual Speed) to the extent of .20.

The nature of the group-naming tests at once suggests that Factor M' has something to do with concept formation or that it may perhaps be described as the ability to form concepts. Another somewhat different hypothesis regarding these two tests is that they require the ability to generalize or to arrive at abstract generalizations. This description perhaps is broader than it need be in reference to the two naming tests in question, but it has the advantage of seeming to apply more readily to some of the other tests in the list. On the other hand, it is somewhat too similar to our description of Factor A' (Perception of Abstract Similarities) to clearly distinguish that factor from Factor M'. For these reasons, Concept Formation seems to provide the more fruitful hypothesis for further research.

Attention has been called earlier to the fact that some of the tests included in the list for Factor M' have been reported by other

investigators to be loaded on factors called Induction. It is suggested that not only A' and B' but also M' are related to induction. Thus there may be several different factors involved in induction, of which we have tentatively identified or suggested hypotheses regarding three.

The highest loading for Verbal Analogies, though it is not strikingly high, is that of .33 on Factor M'. This test is also loaded on Factor B' (Hypothesis Verification) and Factor H' (Deduction). Word Squares, which is similar to Verbal Analogies, has a loading of .24 on this factor. Figure Analogies and Picture Analogies have smaller loadings of .18 and .14, respectively.

Turning to the various series tests, they are loaded as follows: Letter Series .26; Figure Series .23; Number Series .16; Mixed Series .12; Series -.01. It has been noted that analogies and series tests involve educing relations or principles. Perhaps those which appear with moderate loadings on this factor place some premium on the ability to characterize the relations or principles in precise verbal terms--in other words, to form a clear verbal concept. Although such an ability probably is not essential to the solution of all the items in such tests, it seems reasonable to suppose that it would be useful in a number of them. The Series test, it will be recalled, is a nonverbal test in which the progressions for the most part are pretty obvious, almost on a perceptual or intuitive level. This observation would account for the clearly negligible loading for this test.

Matrices VI has its highest loading, .29, on this factor. Of the subtests of the Progressive Matrices test, only E has a loading above .28 on Factor M'; D, C, and B have loadings of .17, .14, and .03, respectively. The general line of argument advanced in the case of analogies and series items is applicable to matrix tests. The more obscure relations or principles of progression would be expected to present more conceptual difficulty and hence demand a greater degree of conceptual ability. The progressively higher factor loadings for the successive subtests substantiate this argument. Possibly, too, the grouping of similar items in separate subtests in the Raven test has some bearing on their generally lower loadings on this factor than that for Progressive Matrices VI. In this test, different kinds of matrix items, even including some based on numbers and letters instead of geometric figures, are presented in scrambled order. The consequent necessity to change set from one item to another may contribute to the loading of this test on Factor M'.

The ability to formulate precise verbal concepts may reasonably be expected to assist in solving arithmetic problems presented in verbal form, and it will be noted that Arithmetic has a loading of .20 on Factor M', its second highest loading in this study.

We may also venture an explanation for the loading of .26 on Forms, which has its highest loading of .43 on Factor D', Perceptual Speed. This, it may be recalled, is a test in which the subject applies rules to combine a series of five non-meaningful geometrical designs to yield a single design. The test is set up with three different designs. The rules provide that a combination of two identical ones yields the same one while a combination of two different ones yields the third one. Some subjects may notice, however, that they can short-cut the process by learning to extend the rules to the combinations of three or perhaps even four or five designs. Thus, for example, a series of two designs that are alike and then one that is different always yields the third; a series of one design followed by a repetition of a different one always yields the third; and so on. With these rules the subject can greatly improve his performance. Although probably not many subjects would hit upon such a plan, a few may have. Those who get such an idea may be using the ability to form concepts. Thus although the test symbols themselves are not readily verbalizable, nevertheless facility in verbal concept formation may be advantageous in taking the test. As was noted earlier in our discussion of Factor D', Perceptual Speed, Coombs has reported that the Forms test was loaded .37 on a factor he very tentatively interpreted as inductive in nature. If, as we think, M' is one aspect of induction, then our findings for the Forms test are not in disagreement with Coombs'.

The loading of .24 on Factor M' for Education is consistent with the interpretation here offered tentatively, in that it may be supposed that Education would be related to the ability to formulate verbal concepts.

Whatever the nature of Factor M', the ability in question is quite distinct from that required on either the two Verbal Classification subtests or the three Figure Classification variables, which have negligible loadings of from .05 to .08. Although at first thought these tests would seem to involve a type of ability also required for the Picture-Group Naming and Word-Group Naming tests, such is clearly not the case, regardless of whether our hypothesis about the nature of Factor M' is correct. If our hypothesis does prove to be tenable, perhaps the explanation lies in the fact that for the classification tests the concepts required do not have to be so precisely formulated and expressed as those involved in the naming tests. Introspection seems to support the point of view that one can be successful on classification tests--or at least on those we used--with much more vaguely defined concepts than those credited as correct in the naming tests.

There remain for brief mention three factors that we believe are best considered as residuals: E', G', and I'. These factors have few loadings that are sufficiently high to lend confidence to interpretations, and it was found impossible in rotation to find a

completely satisfactory simple structure for them. For each of these, we have compared the loadings with factors previously identified by other investigators and have failed to find any leads to their interpretation. Moreover, we have no new hypotheses as to their nature to advance.

Factor E' -- (residual)

Test No.	Test Name	Loading
13	Figure Classification IIA	.37
41	Picture Classification	.33*
37	Painted Blocks	.30
20	Identical Forms	.26
66	Education	-.26*

Picture Classification has its highest loading on this factor, and the loading of .30 for Painted Blocks is close to its maximum loading of .32 on J', the Number factor.

A satisfactory hypothesis for this factor must explain, in particular, why the loading on Figure Classification IIA, which consists of the simpler types of problems in the Figure Classification II booklet, is .37 while that for Figure Classification IIB is .01 and that for Figure Classification I, a different type of figure classification test, is -.01. We have no such hypothesis to venture and hence regard this factor as a residual.

Factor G' -- (residual)

Test No.	Test Name	Loading
39	Picture Analogies	.35*
36	Overlapping Circles	.34*
66	Education	.26*

All three of the variables listed have their highest loadings on Factor G'. (Education has a negative loading equally large on Factor E'.) In addition, Nim, the match game test, has its highest loading of .23 on this factor. All other tests with loadings over .20 are nonverbal and nonnumerical in character, but none of the loadings is high and we have been unable to explain the factor.

Factor I' -- (residual)

Test No.	Test Name	Loading
12	Figure Classification I	.33*
32	Number Series	.31
18	Forms	.29
37	Painted Blocks	.29
2	Arithmetic	.28

Figure Classification I has its highest loading, .33, on Factor I', and this is the highest loading for the factor. All the tests are nonverbal and several are significantly loaded on J', the Number factor, although the best tests for J' are not loaded on I'. We have not been able to interpret this factor satisfactorily.

PART III

SUMMARY AND CONCLUSIONS

The investigations described in this report were made primarily for the purpose of attempting to clarify factors in the realm of reasoning.

Part I reports a factor analysis of 38 Air Force Tests for which the intercorrelations were extracted from a larger matrix available in the Army Air Forces Aviation Psychology Program Report No. 5. For this study we were thus not able to control the variables to be analyzed so well as might have been desired. The data were reasonably satisfactory for our aim, however, which was to clarify bases for deciding which of the many Air Force tests should be in a larger battery to be administered to a single sample and to suggest hypotheses to be explored. The particular Air Force tests selected for the 38-variable matrix included some that had been tentatively identified in various Air Force studies as loaded on factors allied to reasoning and some reference tests for other kinds of factors that we wanted to separate clearly from reasoning. Ten factors, of which eight are interpreted, were extracted by the complete centroid method, and the reference frame was rotated to an oblique simple structure. Some of the factor identifications discussed in Part I -- even for relatively well-known factors -- were made very tentative because of the little control we had over the reference tests.

Part II describes the major factor analysis experiment that we did. Sixty-five tests were administered to a group of Army men stationed at Fort Jackson, South Carolina, so selected that their scores on Aptitude Area I of the Army Classification Battery would be as representative as possible of the expected population of Army recruits for the next few years. Scores on the 65 tests plus Education were available for 200 men. The scores on all variables were "normalized," and the Pearson product-moment intercorrelation coefficients were computed. Sixteen factors, of which 13 could be interpreted at least tentatively, were extracted by the complete centroid method. The orthogonal reference frame was rotated to an oblique simple structure.

1. Factors Common to Both Studies

The factors that showed up most clearly in the first analysis were Number, which was also identified in the second study, and the well-known Verbal factor which in our second study we chose to call Verbal Relations. Factor A in the first study, called Space, is probably identical to Thurstone's Space 1 and to the factor that we similarly name in our second study, L'.

It was suggested that Factor D in the first study, called Visualization, might be the same as Thurstone's second space factor. In our second study, P', which we called Space 2, also seems like Thurstone's second space factor. It was noted in the discussion of Factor P' that it was loaded for Mechanical Information as well as for Mechanical Movements

and not so highly as had been anticipated for Surface Development. Perhaps the factor that has been called "Mechanical Experience" by Air Force investigators is the same as Thurstone's Space 2 factor, especially since Thurstone in his mechanical aptitude study also reports even higher loadings for Mechanical Experience and Electrical Experience variables on his Space 2 factor than for Mechanical Movements and Surface Development. Since neither Thurstone's results nor ours reveal a separation into two factors, it is probable that only the one factor is sufficient to account for both Space 2 and "Mechanical Experience." It would appear that further work should be done to clarify the nature of the factor.

In the first study, Factor E was interpreted as Perceptual Speed, although the identification was not compelling. Similarly, in our larger study, Perceptual Speed seems to be the best explanation for Factor D', and again it is not conclusive. The Thurstones, in Factorial Studies of Intelligence, report that "the perceptual-speed factor P has been one of the most troublesome of the primaries. Its existence has been clearly indicated, and it has appeared in all of the test batteries that have been analyzed so far. The difficulty with this factor is that we have not been able to locate clearly its bounding hyperplane. To do this, we must find tests which have practically zero saturation on the factor and others in which the saturation is appreciable." Apparently, then, ours are not the first studies in which the Perceptual Speed factor has been difficult to identify, and yet we are convinced that such a factor is operative in many test situations apart from the more recently named speed of closure and flexibility of closure factors.

2. Factors Unique to the 38-Variable Study

The Memory factor, F, identified in the first study, has no counterpart in the second. This is as we expected, since we did not consider it essential to identify a memory factor in our larger study. Nor does Factor J in the first study, which we tentatively suggested might be a Visual Pursuit factor, have any corresponding factor in the second. Block Counting was the test with the highest loading on Factor J. In the larger study its highest loading was on Factor D', interpreted as Perceptual Speed, and its second highest loading on Factor L', Space 1. Our second study did not include the other tests that were loaded on Factor J, although Spatial Reasoning, like the Circles test in our larger study, is an adaptation of Thurstone's Marks test. There are some slight evidences of similarity between Factor J and Factor F', interpreted as Flexibility of Perceptual Closure, but they are certainly no more than suggestive at best.

The other factor in the 38-variable study, G, did not lend itself to satisfactory interpretation. Its loadings, in order of decreasing size, were for Figure Analogies, Spatial Visualization II (Painted Blocks), Figure Classification (corresponding to our Figure Classification I), Arithmetic Reasoning, Spatial Visualization I (Paper Folding), and Reading Comprehension. In our larger study we included tests either identical to or very similar to all of these, but no factor corresponding to

Factor G was discovered. Figure Classification I, Figure Analogies,and Reading II had loadings above .20 on Factor A'; Painted Blocks and Arithmetic had loadings above .20 on Factor M'; Paper Folding had a very small communality in our second study, with loadings as high as .21 only for Factors L' and P', the two space factors. Thus it appears that possibly Factor G in our smaller study was separated into A' and M' in our larger study.

3. Reference Factors Unique to the 66-Variable Study

The second study clearly confirms the Word Fluency factor (K') and the Ideational Fluency factor (N'). The tests included as reference variables for these factors had high loadings on them, and the other tests significantly saturated on them were entirely reasonable.

The interpretation of Factor N', Speed of Perceptual Closure, was also quite clear. With the large number and variety of tests included in the battery, the fact that only tests requiring visual perception were significantly loaded on this factor probably means that it is restricted to the perceptual domain. Likewise, the list of tests loaded on the factor somewhat more tentatively identified as Flexibility of Perceptual Closure, F', leads us to believe that it, too, is restricted to the perceptual domain. This study does not indicate, of course, whether the abilities in question extend beyond the visual modality.

4. Reasoning Factors in the 66-Variable Study

The reader may have noted that in our discussion of the several factors in Part II we classified Factor F' with the factors that apparently have something to do with reasoning. This grouping resulted from the fact that most of the tests loaded on this factor are also loaded on other factors that seem to fall within the realm of reasoning. It may also be pointed out that other studies have shown that so-called reasoning tests are loaded on factors interpreted as flexibility of closure. Thus Thurstone has reported a loading of .42 for the Primary Mental Abilities Reasoning composite on his Factor E, Perceptual Closure, in A Factorial Study of Perception. The studies of Yela and Botzum, as well as Thurstone's mechanical aptitude study, also indicate that the flexibility of closure factor is correlated with reasoning factors.

In our 66-variable study we offered tentative interpretations of four other factors that more nearly resemble reasoning in the traditional sense than does Flexibility of Perceptual Closure. One such factor, H', with its highest loading on False Premises, we interpreted as Deduction or the ability to draw correct inferences. This factor, although it did not have significant loadings on many of our variables, agrees quite well with factors that other investigators have called "Deduction."

The other three reasoning factors perhaps might all be regarded as having something to do with inductive processes. The one that we have referred to as "Hypothesis Verification" (B'), which has its highest loadings on three of the Progressive Matrices subtests, is apparently most like the factor that others have regarded as inductive. Attention was

directed to the differences in loadings of certain pairs of tests that are similar except that one is presented in multiple-choice form whereas the other is presented in completion form. These comparisons suggest that Factor B' is concerned primarily with the verification of hypotheses rather than with their formulation. Since others have used the term "induction" to describe a factor that has appeared to be concerned with "seeing" rules or principles, it has seemed desirable to describe our Factor B' in somewhat different terms.

Factor B' is apparently a "power" factor, as indicated by the markedly higher loadings for Progressive Matrices B, C, and D (for which the subject had ample time) than for Progressive Matrices E (which was affected by the reduction in total time for the entire booklet, as explained in Chapter C of Part II). Other tests loaded on B' are Practical Situations, Verbal Analogies, False Premises, and certain series tests.

In addition to Factor B', both Factor A' and Factor M' may represent components of the factor that others have described as Induction. Factor A', with its highest loadings for Verbal Classification II and I, Figure Analogies, and Word Squares, we have termed "Perception of Abstract Similarities." A comparison of the operations that the various tests in the list for this factor seem to involve suggests that this description fits the factor better than the more general term induction, seeing relations, educing principles, or classifying ability.

Factor M' was most significantly loaded for Picture-Group Naming, Word-Group Naming, and Verbal Analogies. It was also involved in other tests that have been considered inductive in character -- certain of the matrices variables, Forms, and Letter Series. The fact that the two group-naming tests have high loadings suggests that the particular aspect of induction concerned in this factor is the formulation of precise verbal concepts. We tentatively have assigned the name "Concept Formation" to Factor M'.

5. Residual Factors in the 66-Variable Study

Little further need be said about the factors that were referred to as residuals, except perhaps to point out that our study leaves unexplained some of the variance in the Figure Classification tests of both kinds and in the Picture Classification tests. Probably it would be worth while to explore these more intensively.

6. Comparison with Other Hypotheses About Reasoning

A brief summary now will be given of some of the hypotheses about reasoning that have not been confirmed by this study. It will be recalled that Part I contains a digest of Air Force hypotheses advanced as possible explanations of factors referred to as Reasoning I (General Reasoning, best identified by Arithmetic Reasoning), Reasoning II, Reasoning III,

Integration I, Integration II, Integration III, Planning, and Judgment. None of our factor lists correspond with the lists for these factors, nor do the hypotheses suggested to account for them seem to describe any of our factors. Further, we have found no factor that corresponds with Thurstone's tentatively identified "restrictive task ability."

It is reported that Zimmerman, in re-rotating the reference axes of Thurstone's Primary Mental Abilities study and two other AAF studies, identified one of three reasoning factors as a classifying ability, common to Thurstone's Sound Grouping and Figure Classification tests.* Although our battery contained a number of classifying tests, including Thurstone's Figure Classification, this hypothesis does not seem to fit any of our factors. It was noted, however, that this test appeared on a residual that we were unable to interpret.

Our results do not confirm Rimoldi's suggestion that the ability to educe relationships is a factor distinct from the ability to educe correlates.** It should be pointed out, however, that our study provides no crucial test of the hypothesis that they may be distinct. Nor does our study confirm his Factor A (a dynamic process involving the interplay of both analysis and synthesis in complex situations -- the ability to try different kinds of combinations) or his Factor G (the ability to bring different parts together into a meaningful solution, similar to Mieli's "globalization"). Although one of our factors (A') shows some similarity to his Factor D (an ability involving the relation of likeness and its opposite), the similarity is not sufficient to indicate that the same factor is operating.

Perhaps it should be mentioned explicitly that not only did our major study fail to confirm a "general reasoning" factor of the type posited in several of the Air Force studies, but also it did not yield any factor to which the description "nonverbal reasoning" seemed to apply. The nearest thing to a nonverbal reasoning factor that we found was a factor that we believe is better described as Flexibility of Perceptual Closure -- which, to be sure, appears to be nonverbal and to be related to the reasoning realm. Nor did we discover any factor fully corroborating Spearman's "g" among our first-order factors, although perhaps our Factors A', B', and M' are all related to "g." The British Air Ministry test, Matrices VI, said to be a good measure of "g," had a loading of .23 on Factor B' and .29 on Factor M'.

---

*Guilford, J. P. et al. A factor-analytic study of reasoning abilities. I. Hypotheses and descriptions of tests. Reports from the Psychological Laboratory, The University of Southern California, No. 1, June, 1950.

**Rimoldi, H. J. A. The central intellective factor. Psychometrika, 1951, 16. 75-101.

7. The Difficulty of Constructing Factorially Pure Tests

Both the analyses reported herein have lent support to the view that it is difficult to construct factorially pure tests. This difficulty was anticipated especially for the realm of reasoning, because the reasoning processes must take place in some medium. The situation with respect to the factorial complexity of the tests that are best for identifying reasoning factors, however, does not appear to be strikingly different from that for the reference tests for most of the other kinds of factors. Thus Verbal Classification I and II, with the highest loadings on Factor A', Perception of Abstract Similarities, have loadings of .25 and .20 on Factor C', Verbal Relations.

Progressive Matrices B and C, two of the best tests for Factor B', have no other loadings above .15; and Progressive Matrices D, also high on Factor B', has one other loading as high as .21, that on Factor F'. Perhaps the somewhat different picture for Progressive Matrices E is accounted for, at least in part, by the reduction in the time limit for this test that has been explained before. The fact that Progressive Matrices B, C, and D did not have appreciable loadings on the other factors in our study does not mean, of course, that they are pure tests of Factor B'. Although the loadings on Factor B' for the first three of the subtests analyzed, B, C, and D, are not so high as might have been hoped (being in the neighborhood of .50), however, these tests seem very promising for use in classification of a group of subjects who may have below-average verbal abilities. Additional studies should be undertaken to isolate the other factors that contribute to the variance of these subtests.

False Premises, with the highest loading on Factor H', interpreted as Deduction, also had a loading of .30 on Factor B', referred to as Hypothesis Verification. Unfortunately, no other test had a loading above .31 on Factor H'. Thus, despite the large number of nonverbal tests that were included in our study, none of them turned out to be a good test of the ability referred to as Deduction for our sample of subjects. This finding suggests that Deduction, by its very nature, may be limited to the verbal realm.

Picture-Group Naming, with the highest loading, .44, for Factor M', identified as Concept Formation, has a loading of .28 on Factor N', Speed of Closure, and .20 on K', Word Fluency. Word-Group Naming and Verbal Analogies, each with a loading of .33 on Factor M', have two or three other loadings of .20 or above on other factors.

8. Nonverbal Tests of "Reasoning"

If for some reason one were seeking a battery of nonverbal tests of reasoning factors, our study would suggest that he could do best in testing Hypothesis Verification by Progressive Matrices B, C, and D and in testing Flexibility of Perceptual Closure by Figure Classification IIA

and IIB, Map Planning, and Camouflaged Outlines. For Perception of Abstract Similarities, one might choose to use Figure Analogies and Figure Classification I, although their loadings are not high. The nonverbal test with the highest loading on our deductive factor was Identical Forms, but this test hardly has the characteristics that would be expected of a good test of deductive ability, and no other nonverbal test that we studied seems promising as a test of Deduction. For Concept Formation, which by its very nature is a kind of verbal factor, Picture-Group Naming might be used, although the responses to it are by necessity verbal. The loadings of Progressive Matrices E and Matrices VI, although not high, are close to .30 and may be suggestive.

Finally, it may be noted that the loadings of Picture Classification, Figure Classification I, Figure Classification IIA, and Picture Analogies on factors that we were forced to regard as residual may indicate that these types of tests are worthy of more intensive exploration in the nonverbal field.

No discussion has been presented herein of the inter-relations of the oblique factors obtained in our 66-variable study. Mr. Leonard Matin, a graduate student in the Department of Psychology of the University of North Carolina, has computed the intercorrelations of the factors and is working on a second-order factor analysis based on this matrix. The results of this analysis will be reported elsewhere.

APPENDIX I

TABLES FOR THE PRELIMINARY STUDY

TABLE 2

Tes

Ari
Com
Dec
Dia
Fig
Fig
Ins
Mec
Num
Num
Pla
Pla
Pla

Pra
Rea
Rou
Spa
Spa
Spa
Spe

Page

N

1/
2/
3/

4/

5/

TABLE 1

Rotated Factor Loadings of Selected Air Force Tests

Test	Reasoning (Nonverbal)				Planning and Foresight							Integration				Memory		Mech.	Percep.		1/ Care.	2/ Classification			
					I			II								I	II		I	II		12/42	7/43	11/43	9/44
	R_I	R_{II}	R_{III}	I_{III}	R_I	J	Pl.	R_I	J	Pl.	I_{III}	I_I	I_{II}	R_I	I_{III}	R_I	R_I	R_I	R_I	R_I	R_I-V	R_I	R_I	R_I-N	R_I
Arith. Reas.	55	-04	00	07	48	10	13	50	04	06	07	04	00	50	16	47	68	56	49	55	63	36	48	58	47
Comp. Plan.	41	15	01	31				29	36	01	33														
Decoding	36	30	37	00																				46	
Dial-Tab. Read.																								46	24
Figure Analo.	35	40	31	28								08	04	33	38										
Figure Class.	03	16	32	38																					
Instr. Comp. 3/	-01	36	04	01								11	11	16	-04									30	13
Mech. Princ.	25	01	00	20	19	05	16	21	00	09	13								25	20	34	15	27		31
Numer. Oper. I	(18	11	07	02				(14	14	03	03	01	02	14	-09									(56	-02
Numer. Oper. II												07	08	07	04										08
Plan. Circuit					10	19	40																		
Plan. Course								18	10	06	33	06	17	28	46										
Plan. Air Man.	25	01	-01	33	30	07	51	12	-11	46	44	01	06	17	49										
					(13	39	36	03	30	28	-07														
Pract. Judg. 4/								40	45	08	01														
Reading Comp.	33	27	03	11	23	13	17	19	04	18	02	16	26	19	22	39	40	22			60	27	26	48	28
Route Planning								27	11	47	39	17	15	18	36										
Spat. Reas.	46	05	38	38	44	14	12																		
Spat. Visual. I	34	32	21	18								01	03	39	34										
Spat. Visual. II	44	35	36	17																					
Speed of Iden. 5/	-08	31	03	16	02	22	04	-08	-05	01	12	04	02	-03	10	-03	-04	-01	-02		-03	02			
Page Reference	113-122				180-191							215-225				261-268		333-339	408-418		686-695	798-819			
N	200				202			170				266				179	238	153	392	392	354	4774	3000	1900	8158

1/ This factor was interpreted as an undifferentiated combination of a general reasoning factor and the verbal factor. Refer to text.

2/ This factor is an undifferentiated mixture including, perhaps, a general reasoning factor and the number factor.'

3/ The data given here are those for the part of the original test that eventually became test C1616C, even though some of the loadings on factors called reasoning for the other part exceeded .24. The reason for this is that the matrix of intercorrelations that we reanalyzed included only test C1616C.

4/ As nearly as we have been able to follow the evolution of this test, both the form used in the first Planning and Foresight study and the two forms used in the second study were based on nonmechanical items, as was the form used in the correlation matrix we analyzed. The loadings in the second row under Planning and Foresight II are for items that appeared to emphasize work planning.

5/ The form of this test used for these analyses provided an element of face validity through use of pictures of airplanes, while the form involved in the matrix of correlations we reanalyzed used meaningless symbols.

TABLE 2

Intercorrelation Matrix for 38 Air Force Tests

Test	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		
2	39																	
3	35	59																
4	25	34	38															
5	30	35	30	15														
6	20	22	22	13	17													
7	29	33	26	16	26	39												
8	28	27	34	24	22	09	24											
9	31	42	42	28	25	23	37	31										
10	29	47	51	35	31	10	26	43	48									
11	29	40	40	29	14	15	33	33	41	38								
12	36	31	25	25	17	10	28	31	33	28	28							
13	26	47	41	17	31	12	29	15	23	27	28	17						
14	39	55	63	33	23	14	23	45	47	48	47	31	33					
15	13	22	24	18	06	23	21	23	31	27	37	14	18	30				
16	36	46	44	25	29	27	43	30	48	37	36	23	28	40	33			
17	26	37	41	28	11	21	25	30	39	34	43	17	17	35	27	36		
18	30	45	32	24	28	23	35	23	32	23	37	21	36	31	25	41	36	
19	25	36	32	19	13	33	33	28	29	24	18	21	23	31	28	22	21	20
20	38	49	52	34	18	38	47	32	41	42	45	31	23	46	36	39	43	36
21	36	31	27	07	24	19	26	34	14	14	15	22	23	32	20	20	10	23
22	34	48	39	27	36	27	35	17	39	35	33	22	30	28	23	32	30	44
23	23	34	33	23	15	19	20	16	21	20	21	19	25	31	16	27	27	25
24	22	41	42	21	24	30	35	28	39	43	30	26	26	49	37	31	32	34
25	32	48	39	28	34	25	39	19	40	36	36	28	33	37	34	37	30	51
26	22	34	37	15	79	12	18	07	12	24	-02	18	41	28	17	31	24	45
27	39	49	40	24	35	33	51	26	46	37	36	27	31	38	34	49	33	44
28	28	30	26	18	21	32	47	29	34	31	32	30	20	32	25	37	30	27
29	34	42	48	27	27	18	24	39	41	47	40	29	27	52	20	33	33	29
30	31	49	45	23	55	14	25	25	32	40	25	21	38	34	18	36	25	41
31	28	31	34	22	24	20	21	33	36	46	31	22	27	43	24	27	25	28
32	18	38	48	27	12	05	02	28	37	50	36	15	25	53	22	16	31	18
33	19	25	19	07	33	26	39	04	24	14	08	13	17	12	23	33	12	27
34	22	34	26	13	34	26	38	08	26	18	14	13	21	20	22	37	17	30
35	06	15	25	14	05	03	-03	16	15	25	24	05	14	29	07	01	17	02
36	23	34	35	20	33	08	12	15	23	25	22	13	25	27	12	22	21	26
37	28	50	52	26	35	18	24	15	36	34	26	18	35	39	21	40	27	38
38	21	31	30	20	13	20	32	28	32	36	36	20	23	35	24	21	30	23

Decimal points have been omitted.

TABLE 2

Intercorrelation Matrix for 38 Air Force Test (Continued)

Test	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20	39																		
21	13	17																	
22	13	36	17																
23	11	26	13	29															
24	30	40	25	29	23														
25	17	44	19	42	29	36													
26	05	24	24	28	18	26	28												
27	23	47	27	45	31	35	52	32											
28	32	44	20	23	17	34	27	13	40										
29	25	38	22	28	23	33	29	26	35	39									
30	13	25	25	35	24	27	41	57	41	18	33								
31	16	35	22	26	21	25	25	10	37	28	37	33							
32	16	30	07	18	16	24	21	14	21	15	40	32	39						
33	12	25	16	31	23	19	38	28	52	23	10	29	17	-02					
34	13	28	15	37	28	20	41	32	55	23	17	35	22	08	67				
35	07	13	-03	04	01	09	04	06	02	01	18	18	21	48	-13	-06			
36	10	23	13	27	22	19	26	31	27	14	28	41	26	34	13	20	25		
37	13	31	17	37	33	28	46	40	49	16	30	52	30	35	40	50	13	34	
38	25	39	11	24	21	26	23	09	36	30	29	20	36	32	16	12	18	20	18

Decimal points have been omitted.

TABLE 3

Centroid Factor Loadings for the Preliminary Study

Test	I	II	III	IV	V	VI	VII	VIII	IX	X	h^2
1 Map Memory	53	-07	07	-16	11	06	19	-27	-06	13	46
2 Figure Analogies	73	12	-02	03	12	06	24	-05	-16	09	66
3 Spatial Visual. II	71	10	-23	01	05	03	13	05	-20	14	65
4 Plan. Air Maneuv.	41	01	-18	07	12	-03	07	-11	04	06	24
5 Vocabulary	51	33	26	-40	16	-18	-25	-07	08	09	74
6 Estim. of Length	39	-17	26	18	11	11	-24	14	-16	-14	43
7 Speed of Ident.	55	-22	36	17	08	09	-14	04	04	09	55
8 Memory Plane Sil.	48	-31	-18	-26	-18	-08	-05	-15	11	-15	52
9 Direct. Orient.	63	-16	-08	12	-11	01	05	11	12	17	51
10 Visual. of Maneuv.	63	-01	-31	-04	-06	-09	-10	06	16	18	58
11 Plan. a Circuit	57	-23	-22	16	08	09	14	-09	16	-08	52
12 Visual Memory	43	-18	02	-10	06	07	11	-20	11	13	32
13 Figure Class.	50	15	04	-05	10	14	17	16	-14	-15	41
14 Spatial Visual. I	70	-12	-27	-11	-11	18	12	07	-04	15	68
15 Object. of Percept.	43	-07	04	20	-13	08	-06	20	18	-17	36
16 Decoding	62	-08	14	11	-05	-13	08	10	02	15	48
17 Route Planning	53	-13	-15	21	12	-22	-10	10	03	-06	45
18 Flight Formation	59	08	19	05	16	-16	13	07	10	-22	52
19 Pattern Assembly	41	-29	03	08	10	30	-17	10	-14	11	43
20 Block Counting	67	01	-08	32	20	18	-20	-12	13	05	70
21 Plane Name Memory	37	-14	18	-30	-05	14	11	-11	-07	-11	34
22 Planning a Course	57	16	10	14	08	-06	11	-13	05	-06	43
23 Comp. Planning	43	09	03	11	-03	-01	-13	-07	-17	-12	27
24 Camoufl. Outlines	57	-10	03	02	03	17	08	17	09	-05	42
25 Spatial Reasoning	62	15	17	19	04	01	15	-06	10	02	51
26 AAF Word Know.	50	48	28	-43	22	-09	-16	25	13	05	90
27 Dial and Tab. Read.	70	05	26	18	-16	04	-03	-03	04	07	63
28 Spat. Orient. I	51	-31	10	05	08	10	-19	03	11	09	44
29 Spat. Orient. II	60	-12	-20	-10	02	02	03	02	03	12	44
30 Reading Comp.	61	38	05	-25	03	-09	06	10	-02	-03	61
31 Instrument Comp.	54	02	-18	-11	-22	13	-09	04	12	-09	43
32 Mech. Principles	49	12	-59	-04	-09	09	-03	13	-11	05	65
33 Numer. Oper. I	43	21	48	20	-31	-03	-11	-07	-07	08	62
34 Numer. Oper. II	50	31	40	18	-32	-08	-06	-08	-11	09	68
35 Mech. Inf.	22	08	-50	-09	06	10	-10	08	-15	-10	38
36 Pract. Judgment	44	27	-14	-10	08	-05	03	02	-09	02	31
37 Arith. Reasoning	60	34	05	07	-14	-06	18	07	-19	11	60
38 Complex Coord.	48	-06	-18	09	-04	16	18	06	20	-08	38

Decimal points have been omitted.

TABLE 4

Distribution of Tenth-Factor Residuals for the Preliminary Study

Value of Residual		Frequency
+100 +109		2
+090 +099		1
+080 +089		4
+070 +079		3
+060 +069		18
+050 +059		18
+040 +049		16
+030 +039		40
+020 +029		57
+010 +019		81
+000 +009		94
-010 -001		98
-020 -011		78
-030 -021		64
-400 -031		44
-050 -041		34
-060 -051		18
-070 -061		13
-080 -071		7
-090 -081		8
-100 -091		4
-110 -101		1
	Total	703

Decimal points have been omitted.

TABLE 5

Oblique Factor Matrix for the Preliminary Study

Test	A	B	C	D	E	F	G	H	J	K
1 Map Memory	08	14	00	08	03	45	21	16	24	22
2 Figure Analogies	00	15	11	23	15	21	47	23	26	21
3 Spatial Visual. II	10	12	12	37	16	12	45	28	11	20
4 Plan. Air Maneuv.	11	12	01	18	02	14	14	14	21	26
5 Vocabulary	07	68	05	10	03	23	-06	-04	01	15
6 Estimation of Length	02	07	11	17	51	04	04	01	-02	-02
7 Speed of Identification	15	16	12	-02	47	12	03	19	11	01
8 Memory for Plane Sil.	57	02	05	19	-01	44	-06	09	00	15
9 Directional Orient.	39	06	14	09	24	03	20	37	10	05
10 Visual. of Maneuvers	44	25	11	28	09	05	10	29	06	18
11 Planning a Circuit	33	00	-01	18	14	22	18	17	34	20
12 Visual Memory	22	11	-04	01	06	35	08	18	22	14
13 Figure Class.	-03	14	04	18	20	06	43	02	16	-05
14 Spatial Visual. I	37	02	10	31	17	20	35	30	11	01
15 Object. of Perception	31	02	19	08	24	-11	06	04	13	-12
16 Decoding	23	13	15	-01	27	04	24	38	03	11
17 Route Planning	26	16	03	21	29	01	11	26	02	30
18 Flight Formation	12	30	02	-01	19	11	25	09	21	16
19 Pattern Assembly	11	00	01	24	48	12	11	15	03	-07
20 Block Counting	13	23	18	37	26	08	00	02	42	25
21 Plane Name Memory	16	04	01	03	08	42	14	-01	08	-06
22 Planning a Course	05	19	19	11	03	14	18	05	31	24
23 Competitive Planning	03	05	27	31	11	11	06	-06	06	17
24 Camouflaged Outlines	25	12	02	09	30	07	27	15	18	-09
25 Spatial Reasoning	06	18	22	03	10	06	22	11	34	14
26 AAF Word Knowledge	01	79	-05	03	15	-02	15	-03	01	-10
27 Dial and Table Reading	20	11	40	09	20	08	11	14	19	04
28 Spatial Orient. I	31	16	01	09	41	18	-03	20	08	04
29 Spatial Orient. II	33	16	00	23	16	20	21	27	08	13
30 Reading Comprehension	08	42	13	18	01	08	31	04	08	06
31 Instrument Comp.	42	08	24	31	02	12	05	-02	12	-06
32 Mechanical Principles	25	03	13	56	01	-03	29	13	02	10
33 Numerical Oper. I	00	02	58	-01	07	-04	-04	00	04	-03
34 Numerical Oper. II	-01	05	61	06	00	-04	04	02	05	03
35 Mechanical Information	09	04	-02	51	01	03	16	-05	00	10
36 Practical Judgment	01	25	08	28	-01	06	25	05	09	16
37 Arithmetic Reasoning	-03	09	35	19	02	-05	41	18	08	09
38 Complex Coordination	30	01	05	12	07	05	23	10	31	-02

Decimal points have been omitted.

TABLE 6

Transformation Matrix for the Preliminary Study

	A	B	C	D	E	F	G	H	J	K
I	35	27	23	32	27	26	29	23	21	20
II	-46	36	35	20	-46	-38	10	-41	24	-01
III	-25	14	12	-56	26	06	-10	-06	-02	-26
IV	-23	-37	36	04	17	-48	-02	07	27	21
V	-46	57	-73	00	37	12	18	02	27	35
VI	-17	-21	07	24	14	03	08	-42	47	-58
VII	-14	-31	-24	-48	-25	07	71	32	29	-05
VIII	10	13	-24	-16	59	-70	44	34	-45	-58
IX	52	38	-16	-44	-22	-15	-39	-07	46	-16
X	-09	13	-03	-19	07	-17	04	61	-16	01

Decimal points have been omitted.

TABLE 7

Reference Vector Cosines
for the Preliminary Study

	A	B	C	D	E	F	G	H	J	K
A										
B	-01									
C	06	-38								
D	-05	-05	34							
E	-02	14	-32	00						
F	16	-01	-14	14	-18					
G	-27	-11	-26	-06	25	-14				
H	23	-02	-28	-37	37	-14	43			
J	-13	10	03	01	-30	17	-01	-41		
K	-11	14	-03	26	-22	39	-13	14	09	

Decimal points have been omitted.

APPENDIX II

TABLES FOR THE MAJOR STUDY

TABLE 8

Time Limits, Number of Items, and Scoring Formulas for the Major Study

Code No.	Test	Time Limits: Directions	Time Limits: Test Proper	No. of Practice Items	No. of Test Items	Scoring Formula
1	Absurdities	2	6	3	40	R-W
2	Arithmetic	2	10	2	15	R-W/3
3	Block Counting	5	9	25	80	R
4	Camouflaged Outlines	3	13	2	46	R-W/4
5	Cards	2	5	20	120	R-W
6	Circles	6	5	5	15	R
7	Conclusions	3	5	4	20	R-W
8	Decoding	6	15	6	40	R-W/5
9	Designs	3	4	30	300	R-W
10	False Premises	3	6	5	24	R-W
11	Figure Analogies	3	6	7	30	R-W/4
12	Figure Classification I	4	10	3	16	R-W/4
13	Figure Classification II A	4	9	32	128	R-W
14	Figure Classification II B		7		96	R-W/2
15	Figure Series	2	5	3	22	R-W/2
16	Figure	3	5	24	120	R-W
17	First and Last Letters	2	5	-	-	No. Resp.
18	Forms	12	7	12	60	R-W/2
19	Geometrical Puzzles	2	15	1	14	R
20	Identical Forms	1	4	5	60	R-W/4
21	Incomplete Outlines	2	11	3	46	R-W/4
22	Letter Series	4	5	11	24	R
23	Logical Puzzles	2	14	1	17	R
24	Map Planning	4	15*	4	46	R-W/2
25	Matrices VI	1 1/2	13 1/2**	1	58	R
26	Mechanical Information	1	12	0	30	R-W/4
27	Mechanical Movements	2	12	5	38	R-W
28	Mixed Series	2	12	3	40	R
29	Mutilated Pictures	1	4	3	36	R-W
30	Mutilated Words	2	4	4	26	R
31	Nim	4	7	5	20	R
32	Number Series	5	12	6	30	R
33	Numerical Operations I	2	5	8	100	R-W
34	Numerical Operations II	2	5	6	80	R-W/4
35	Numerical Puzzles	1	12	1	13	R
36	Overlapping Circles	8	7	9	90	R-W
37	Painted Blocks	2	12	2	28	R
38	Paper Folding	2	18	1	30	R-W/4
39	Picture Analogies	2	5	2	24	R-W/3
40	Picture Arrangement	2	7	2	20	R

* 3 minutes per page for five pages.

** 1 1/2 minutes for page 2; 4 minutes each for pages 3, 4, and 5 in accordance with British Air Ministry practice.

TABLE 8

Time Limits, Number of Items, and Scoring Formulas for the Major Study (Continued)

Code No.	Test	Time Limits		No. of Practice Items	No. of Test Items	Scoring Formula
		Directions	Test Proper			
41	Picture Classification	1	5	2	40	R
42	Picture-Group Naming	2	7	2	24	R
43	Planning a Circuit	4	14	1	45	R-W/4
44	Practical Situations	1	15	0	20	R-W/4
45	Progressive Matrices B	3	26	1	12	R
46	Progressive Matrices C				12	R
47	Progressive Matrices D				12	R
48	Progressive Matrices E				12	R
49	Reading	2	7	2	24	R-W/4
50	Reading II	3	10	2	15	R-W/4
51	Reasons	1	6*	-	-	No. Resp.
52	Sentence Order	2	6	2	25	R
53	Series	1	6	1	15	R-W/5
54	Street Gestalt Completion	1	3	3	24	R
55	Suffixes	2	4	-	-	No. Resp.
56	Surface Development	3	11	4	28	R
57	Things Round	1	3	-	-	No. Resp.
58	Topics	1	4	-	-	No. Resp.
59	Verbal Analogies	2	6	2	39	R-W/3
60	Verbal Classification I	3	7	12	150	R-W
61	Verbal Classification II		7		150	R-W
62	Vocabulary	2	6	2	50	R-W/3
63	Word-Group Naming	2	8	2	30	R-W/4
64	Word Selection	2	5	2	24	R-W/4
65	Word Squares	3	10**	2	21	R

* 3 minutes per topic for two topics.

** 4 minutes for Part A, 6 minutes for Part B.

TABLE 9

ORDER OF ADMINISTRATION OF TESTS

Test No.	Title	Min.
	Day 1	
41	Pict. Class.	6
17	lst. & Last Let.	7
25	Matrices VI	15
8	Decoding	21
1	Absurdities	8
37	Painted Blocks	14
23	Logical Puzzles	16
16	Figures	8
22	Letter Series	9
30	Mutilated Words	6
36	Overlap. Circles	15
62	Vocabulary	8
2	Arithmetic	12
	Day 2	
5	Cards	7
19	Geom. Puzzles	17
42	Pict.-Group Nam.	9
44	Pract. Situations	16
45-48	Prog. Matrices B-E	29
58	Topics	5
49	Reading	9
12	Fig. Class. I	14
7	Conclusions	8
28	Mixed Series	14
	Day 3	
9	Designs	7
50	Reading II	13
38	Paper Folding	20
33	Num. Operations I	7
3	Block Count.	14
55	Suffixes	6
63	Word-Group Nam.	10
35	Num. Puzzles	13
29	Mut. Pictures	5
53	Series	7
26	Mech. Inf.	13
39	Pict. Analogies	7
6	Circles	11
	Day 4	
20	Identical Forms	5
60	Verb. Class. I	17
61	Verb. Class. II	
11	Fig. Analogies	9
56	Surface Devel.	14
40	Pict. Arrang.	9
24	Map Planning	19
21	Inc. Outlines	13
34	Num. Operations II	7
51	Reasons	7
15	Figure Series	7
4	Cam. Outlines	16
31	Nim	11
	Day 5	
59	Verb. Analogies	8
65	Word Squares	13
18	Forms	19
43	Plan. Circuit	18
32	Number Series	17
64	Word Selection	7
13	Fig. Class. II A	20
14	Fig. Class. II B	
10	False Premises	9
52	Sentence Order	8
27	Mech. Movements	14
57	Things Round	4
54	St. Gest. Com.	4

TABLE 10

Raw Score Ranges and Frequencies Corresponding to the "Normalized" Coded Scores for Each Variable in the Major Study

	1.Absurd.		2.Arith.		3. Block Counting		4. Cam. Outlines		5. Cards		6.Circles		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	38	10	12 15	10	64 72	10	23 35	7	83 103	8	15	17	9
8	34 37	18	11	7	59 63	13	17 22	13	76 82	13	14	20	8
7	31 33	22	9 10	20	51 58	23	14 16	23	62 75	25	13	18	7
6	28 30	32	7 8	36	43 50	33	10 13	41	53 61	38	12	20	6
5	24 27	37	4 6	46	36 42	43	7 9	35	43 52	36	9 11	37	5
4	19 23	38	2 3	46	31 35	31	5 6	33	33 42	34	6 8	36	4
3	14 18	23	0 1	23	25 30	26	3 4	24	23 32	23	3 5	24	3
2	8 13	12	-1	6	16 24	14	2	13	2 22	15	1 2	18	2
1	-6 7	8	-3 -2	6	3 15	7	-2 1	11	-8 1	8	0	10	1
Total		200		200		200		200		200		200	

	7.Conclusions		8. Decoding		9.Designs		10.False Premises		11.Figure Analogies		12. Figure Class. I		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	8 14	10	29 40	8	211 254	9	13 16	8	26 30	9	11 15	8	9
8	6 7	11	25 28	11	197 210	13	10 12	14	23 25	13	9 10	15	8
7	3 5	29	20 24	25	143 196	24	8 9	24	20 22	30	8	11	7
6	0 2	44	11 19	38	106 142	32	6 7	33	16 19	37	6 7	47	6
5	-1 -2	38	6 10	36	85 105	42	3 5	42	12 15	41	4 5	34	5
4	-3 -4	32	1 5	36	54 84	34	0 2	42	4 11	29	3	32	4
3	-5 -6	21	-1 0	29	39 53	24	-2 -1	18	1 3	22	2	20	3
2	-7 -9	9	-3 -2	9	18 38	15	-4 -3	11	-2 0	13	1	19	2
1	-13-10	6	-7 -4	8	3 17	7	-12 -5	8	-5 -3	6	-4 0	14	1
Total		200		200		200		200		200		200	

	13.Figure Class.IIA		14.Figure Class.IIB		15.Figure Series		16.Figures		17.First & Last Letters		18. Forms		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	73 88	8	53 65	9	17 22	10	90 116	8	17 25	9	37 48	8	9
8	64 72	14	45 52	15	15 16	12	80 89	14	15 16	12	25 36	13	8
7	51 63	22	36 44	22	13 14	19	67 79	25	12 14	27	15 24	24	7
6	41 50	33	28 35	33	11 12	25	55 66	33	10 11	30	9 14	33	6
5	32 40	47	21 27	46	8 10	46	41 54	41	8 9	43	4 8	38	5
4	25 31	30	16 20	32	5 7	47	25 40	32	7	22	0 3	39	4
3	17 24	24	9 15	22	2 4	22	12 24	25	6	25	-3 -1	23	3
2	5 16	14	2 8	13	0 1	11	1 11	14	4 5	21	-7 -4	16	2
1	-40 4	8	-3 1	8	-4 -1	8	-45 0	8	0 3	11	-10 -8	6	1
Total		200		200		200		200		200		200	

TABLE 10 (Continued)

	19. Geom. Puzzles		20. Ident. Forms		21. Incomp. Outlines		22. Letter Series		23. Logical Puzzles		24. Map Planning		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	7	2	44 54	8	27 38	8	20 22	10	15 17	9	41 47	8	9
8	6	8	40 43	13	21 26	16	17 19	15	14	15	37 40	13	8
7	5	9	35 39	24	15 20	23	14 16	30	12 13	29	33 36	24	7
6	4	40	31 34	30	9 14	37	12 13	33	11	30	28 32	30	6
5	3	54	28 30	42	6 8	42	10 11	37	9 10	42	22 27	42	5
4	2	49	24 27	39	4 5	25	7 9	28	7 8	35	13 21	35	4
3	1	31	19 23	23	2 3	26	5 6	24	6	16	2 12	25	3
2	0	7	10 18	13	0 1	17	3 4	13	4 5	17	-2 1	14	2
1			-3 9	8	-4 -1	6	0 2	10	2 3	7	-12 -3	9	1
Total		200		200		200		200		200		200	

	25. Matrices VI		26. Mech. Inform.		27. Mech. Movement		28. Mixed Series		29. Mutilated Picts.		30. Mutilated Words		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	41 48	9	21 25	8	15 24	5	28 33	9	25 30	7	16 20	10	9
8	36 40	11	16 20	16	11 14	17	25 27	16	21 24	14	15	13	8
7	31 35	25	11 15	22	8 10	26	22 24	20	18 20	27	13 14	30	7
6	26 30	36	8 10	35	5 7	30	20 21	30	16 17	39	11 12	25	6
5	21 25	36	5 7	38	1 4	47	17 19	41	14 15	39	9 10	39	5
4	18 20	33	2 4	37	-3 0	31	14 16	37	12 13	32	7 8	33	4
3	13 17	29	0 1	27	-5 -4	20	11 13	30	10 11	25	6	24	3
2	10 12	15	-1	9	-8 -6	16	9 10	11	8 9	11	4 5	16	2
1	1 9	6	-4 -2	8	-17 -9	8	4 8	6	1 7	6	1 3	10	1
Total		200		200		200		200		200		200	

	31. Nim		32. Number Series		33. Numer. Operation I		34. Numer. Operation II		35. Numer. Puzzles		36. Overlap. Circles		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	12 15	7	15 17	4	53 63	8	47 71	9	8	1	71 90	8	9
8	10 11	13	13 14	13	45 52	14	43 46	13	7	3	60 70	14	8
7	8 9	31	11 12	26	39 44	25	36 42	24	6	8	40 59	24	7
6	6 7	43	9 10	27	34 38	32	28 35	35	5	20	22 39	31	6
5	4 5	39	6 8	55	27 33	40	24 27	38	4	45	12 21	45	5
4	3	25	4 5	32	22 26	31	18 23	33	3	57	5 11	34	4
3	2	16	2 3	21	16 21	28	15 17	23	2	44	0 4	25	3
2	1	16	0 1	13	12 15	14	10 14	16	1	18	-4 -1	11	2
1	0	10	-4 -1	9	4 11	8	2 9	9	0	4	-13 -5	8	1
Total		200		200		200		200		200		200	

TABLE 10 (Continued)

	37.Painted Blocks		38.Paper Folding		39.Picture Analogies		40.Picture Arrange.		41.Picture Class		42.Pic.-Group Naming		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	12 23	8	21 27	7	16 22	13	19 20	4	29 34	6	18 19	7	9
8	9 11	11	16 20	16	13 15	17	18	11	27 28	14	16 17	13	8
7	7 8	17	12 15	21	11 12	34	16 17	24	24 26	28	14 15	19	7
6	5 6	25	7 11	36	9 10	29	14 15	45	22 23	29	12 13	32	6
5	4	31	4 6	50	7 8	45	12 13	42	19 21	36	10 11	51	5
4	3	33	1 3	30	5 6	29	10 11	37	17 18	41	8 9	32	4
3	2	32	-1 0	18	3 4	19	8 9	19	15 16	22	6 7	24	3
2	1	25	-3 -2	16	0 2	8	7	12	11 14	18	5	11	2
1	0	18	-4	6	-7 -1	6	1 6	6	7 10	6	1 4	11	1
Total		200		200		200		200		200		200	

	43.Plan. a Circuit		44. Practical Sit.		45. Prog. Matrices B		46. Prog. Matrices C		47.Prog. Matrices D		48. Prog. Matrices E		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	18 22	8	11 12	3	12	54	12	3	12	4	9 12	6	9
8	15 17	12	9 10	25	11	49	11	21	11	13	7 8	22	8
7	11 14	22	7 8	39	10	38	10	44	10	42	6	22	7
6	7 10	28	6	32	9	20	9	51	9	36	5	24	6
5	4 6	37	5	37	8	15	8	34	8	33	4	29	5
4	1 3	32	3 4	36	7	9	7	20	7	28	3	34	4
3	-2 0	31	2	16	6	6	5 6	17	6	18	2	31	3
2	-4 -3	22	1	7	4 5	6	3 4	7	4 5	18	1	16	2
1	-6 -5	8	-5 0	5	1 3	3	1 2	3	0 3	8	0	16	1
Total		200		200		200		200		200		200	

	49. Reading		50. Reading II		51.Reasons		52. Sentence Order		53.Series		54.Street Gestalt Completion		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	22 24	7	13 15	6	26 34	7	23 24	4	12 15	6	17 18	9	9
8	19 21	11	11 12	12	22 25	12	20 22	16	10 11	17	16	12	8
7	16 18	24	9 10	25	19 21	22	18 19	22	9	21	14 15	32	7
6	13 15	35	6 8	35	16 18	37	16 17	32	8	26	12 13	46	6
5	10 12	46	4 5	35	13 15	44	14 15	34	6 7	46	11	34	5
4	8 9	31	2 3	42	10 12	35	12 13	38	4 5	36	10	18	4
3	6 7	27	1	19	8 9	23	10 11	30	2 3	26	9	18	3
2	4 5	14	0	14	7	13	8 9	16	0 1	13	8	15	2
1	-1 3	5	-1 -2	12	3 6	7	3 7	8	-3 -1	9	2 7	16	1
Total		200		200		200		200		200		200	

[illegible] been [illegible]ed.

TABLE 10 (Continued)

	55.Suffixes		56.Surface Develop.		57.Things Round		58.Topics		59.Verbal Analogies		60.Verbal Class. I		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Coded Scores
9	21 29	8	33 47	8	27 35	10	18 35	9	33 35	7	143 152	8	9
8	18 20	13	26 32	14	23 26	16	15 17	15	30 32	16	111 142	14	8
7	15 17	26	20 25	26	20 22	22	13 14	21	25 29	30	92 110	25	7
6	11 14	37	16 19	33	17 19	33	10 12	38	21 24	34	65 91	32	6
5	9 10	38	11 15	43	14 16	40	8 9	42	16 20	39	43 64	41	5
4	7 8	26	8 10	31	11 13	39	6 7	38	11 15	35	19 42	35	4
3	5 6	21	6 7	25	9 10	18	5	18	6 10	19	5 18	23	3
2	3 4	21	4 5	13	7 8	16	3 4	14	2 5	12	- 5 4	13	2
1	0 2	10	0 3	7	3 6	6	0 2	5	-2 1	8	-51 -6	9	1
Total		200		200		200		200		200		200	

	61.Verbal Class. II		62.Vocabulary		63.Word-Gr.Naming		64.Word Selection		65.Word Squares		66. Education		
Coded Scores	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores	Fr.	Raw Scores*	Fr.	Coded Scores
9	124 152	8	35 48	8	23 25	7	21 23	5	50 57	9	14	3	9
8	97 123	14	27 34	15	20 22	15	19 20	16	41 49	14	13	2	8
7	81 96	23	22 26	21	17 19	19	16 18	24	34 40	25	12	38	7
6	63 80	35	16 21	35	14 16	41	14 15	31	27 33	33	11	17	6
5	40 62	38	12 15	39	12 13	37	11 13	40	23 26	42	10	48	5
4	21 39	33	8 11	35	9 11	38	7 10	36	19 22	31	9	37	4
3	2 20	26	5 7	23	6 8	25	4 6	27	14 18	23	8	29	3
2	-13 1	15	2 4	17	4 5	13	3	14	10 13	15	7	20	2
1	-55 -14	8	-3 1	7	0 3	5	-2 2	7	1 9	8	6	6	1
Total		200		200		200		200		200		200	

* The raw scores for this variable represent years of academic education.

Ab
Ar
Bl
Ca
Ca

Ci
Co
Da
De
Fe

Fi
F
F
F
F

F
F
F
G
I

I
I
I
I
I

h^2
66
60
62
52
69
48
28
63
47
42
66
47
68
65
65
62
48
47
50
66
75
56
59
54
75
50
45
77
49
37
26
58
72

Intercorrelation Coefficients (Below Diagonal) and 16th-Factor Residuals (Above Diagonal) for the Major Study

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
Absurdities	1		-07	01	-03	05	02	-03	03	-02	-04	-03	04	00	05	00	-02	03	-03	-01	-02	00	01	-02	-02	02	02	03	01	06	-02	-03	02	-01	-03	01	00	03	00	03	02	-01	02	-02	03	-03	00	-01	00	02	00	-01	00	03	00	-04	04	01	01	03	00	-04	-04	02	-01	-02	04
Arithmetic	2	32		-01	04	02	-05	01	02	03	04	-03	02	00	-01	00	-01	00	00	01	00	-02	01	02	02	01	-02	02	-02	-03	03	00	02	01	02	03	-02	03	00	00	-02	-04	-02	-04	-02	02	-02	00	01	-02	04	03	01	-04	-03	-01	01	03	00	00	01	03	05	-02	00	00	-01
Block Counting	3	24	30		-01	00	-03	-02	04	-03	05	-01	01	02	-03	00	01	00	00	02	01	-03	04	00	01	02	03	02	01	05	00	-03	02	02	-01	01	01	02	-01	03	01	-03	-03	-02	-02	01	-01	00	01	00	02	05	01	-04	-02	02	01	-01	02	01	-03	00	00	-04	-01	01	01
Camouflaged Outlines	4	21	27	41		-02	03	01	03	02	-01	03	-01	-01	00	-02	04	-02	00	01	01	02	-02	-01	-02	02	-02	00	01	02	05	02	01	-03	-01	-02	-02	-02	02	00	-01	04	-06	-04	02	02	-04	-01	00	-02	02	01	02	-02	-01	03	01	-02	-02	00	01	00	01	00	01	02	-01
Cards	5	26	42	52	33		05	03	01	00	00	03	01	01	-01	-02	05	00	-03	-04	04	03	01	01	-03	01	06	-02	-02	-02	01	-03	-02	01	01	-02	02	00	-06	00	-02	-01	01	-02	00	-03	-01	01	00	02	-04	00	00	-01	03	-05	03	-01	02	-01	-02	01	01	01	00	02	-01
Circles	6	24	37	34	33	39		00	03	-02	-02	-01	01	-01	-04	01	-01	04	-05	00	00	02	02	-02	-04	01	06	-03	02	-08	02	-02	-01	02	-01	-04	01	00	-02	-01	-01	05	01	00	-02	02	-02	00	-02	02	-04	02	04	05	00	-04	-01	02	00	-02	02	-03	-01	05	02	-02	-01
Conclusions	7	19	24	10	14	14	18		02	-01	07	00	-04	01	00	00	06	02	02	-01	00	03	02	00	-03	00	03	00	02	-02	02	-01	01	02	-01	-05	-03	-01	01	01	06	-01	-04	-03	02	04	-02	-02	-05	-03	00	-03	00	-06	-01	-03	01	-01	02	-03	-03	-04	01	-02	05	07	01
Decoding	8	39	48	38	45	33	50	27		-05	02	-03	-02	-02	-02	-02	02	01	-04	00	01	-01	06	-04	-04	03	04	00	01	-03	-05	-03	-01	01	00	02	03	00	-04	01	00	-02	02	03	02	01	-01	00	-02	02	-01	-01	01	-02	02	03	04	-02	-02	-03	-01	-03	02	00	00	00	-01
Designs	9	27	35	37	40	43	29	14	35		04	01	05	-03	02	-01	00	00	00	01	00	00	-02	-03	05	-01	00	-03	-03	03	01	02	01	-01	00	02	-05	02	02	-03	-02	01	00	-01	06	05	-01	-01	-01	02	03	-02	-04	-02	01	00	-01	00	-02	-02	00	01	00	04	-03	00	00
False Premises	10	18	33	21	14	22	23	27	27	15		-02	09	01	02	-06	-02	04	-03	01	-03	-01	-02	03	-01	01	00	-01	03	00	00	05	01	-03	-03	-03	-02	02	-05	-04	-02	-04	-01	-04	00	-03	02	01	03	00	05	-02	-03	-02	-01	-02	-03	00	00	01	00	02	02	-04	06	00	01
Figure Analogies	11	29	40	38	48	45	39	27	49	40	36		03	00	-01	02	-02	02	03	-01	02	-02	04	-04	03	02	-01	00	01	02	-01	02	02	-02	04	08	00	01	01	00	-01	01	00	-04	04	01	-02	-01	-02	00	-03	00	02	02	00	00	00	02	-03	-02	-01	02	-03	-01	-02	-04	-01
Fig. Class. I	12	26	42	31	26	33	36	24	39	35	36	47		04	-02	03	02	-02	-01	-02	02	-01	-01	-02	-02	-02	00	-02	01	02	00	-02	00	04	-03	-07	-01	00	-04	-03	-07	07	03	-01	03	-01	03	-02	00	06	-03	02	06	01	-01	01	-02	-01	02	-02	01	-02	-05	01	-03	00	-01
Fig. Class. IIA	13	23	36	48	44	42	41	17	46	34	16	46	43		03	02	03	-01	00	-04	-01	00	-03	06	00	-02	02	02	-01	00	00	00	00	00	-01	-02	00	01	04	03	-02	-02	-01	-04	02	-01	02	-03	00	00	02	-03	01	-01	01	-03	02	02	01	-04	-01	02	00	01	00	-01	01
Fig. Class. IIB	14	24	37	38	41	35	41	26	47	35	30	50	42	63		-01	01	-04	03	-02	00	01	-02	01	02	02	02	-02	-02	00	-02	02	-01	00	01	03	-03	01	-01	03	-01	-04	-01	04	01	-03	01	02	01	-03	00	01	-05	00	00	-03	00	-02	-01	04	-01	02	02	02	-02	02	03
Figure Series	15	21	40	47	37	37	49	21	50	34	16	48	38	45	44		-03	01	01	02	00	-02	-01	-02	02	00	-05	-02	03	06	-02	03	-02	-01	00	02	02	03	04	04	00	-01	00	-02	05	-02	-01	00	-01	-01	03	-02	-01	-01	00	-01	05	-01	-01	05	-02	-01	-02	-02	00	-01	-02
Figures	16	15	35	47	35	67	32	18	36	39	17	36	31	40	33	40		00	01	-05	02	01	01	03	-02	-01	-02	04	-03	-02	-02	01	00	00	00	-02	-04	00	-04	-01	-02	02	-01	-01	-02	-02	00	-01	03	-02	-01	00	06	06	06	00	-02	-01	02	-01	-02	-02	-01	01	-01	02	-01
First and Last Letters	17	30	24	21	16	17	22	26	24	18	21	33	19	25	26	20	13		02	03	-03	-01	05	-02	03	00	04	-03	02	03	00	01	-03	-04	00	-02	00	02	00	02	03	03	-03	-05	-05	-02	04	01	00	03	04	02	-01	00	-02	03	01	00	00	01	-02	-02	03	-03	01	-04	-04
Forms	18	23	33	32	21	18	22	15	30	18	14	35	25	27	26	38	20	24		01	00	04	03	02	02	01	-03	04	-04	04	-01	01	-05	00	02	01	-02	02	02	-02	03	-03	01	00	-04	-01	03	00	-01	02	03	-03	02	02	02	-01	-01	-01	04	-02	-04	01	-02	-01	-02	03	-03
Geometrical Puzzles	19	22	38	49	41	46	38	17	42	37	23	43	36	45	44	45	40	26	30		-02	-02	00	-03	03	00	02	01	02	00	-03	02	-02	-01	01	04	02	-01	03	04	06	04	01	02	00	-01	03	00	-02	-01	05	-02	-03	-01	-01	04	-03	00	01	00	00	00	01	-02	-02	-02	-03
Identical Forms	20	31	19	45	41	28	31	14	33	33	11	28	23	32	30	39	20	14	27	30		01	-02	00	01	-02	-03	03	-04	02	04	-05	06	05	01	01	-01	00	-05	-04	-02	05	02	00	02	02	-03	-02	01	-02	-03	02	00	02	04	00	-01	-01	-01	-01	01	01	00	00	-01	04	07
Incomplete Outlines	21	49	47	38	40	36	49	39	57	40	35	56	45	46	52	52	31	37	46	41	45		-02	04	04	-01	01	-04	-03	-04	-05	-02	00	-03	01	-02	-02	00	00	02	04	-04	04	03	-02	02	02	00	05	02	-02	-01	00	-02	02	01	02	03	00	-02	01	-03	01	03	02	01	02
Letter Series	22	38	50	44	33	36	46	25	58	35	17	48	35	39	40	52	37	29	35	38	34	53		00	00	00	05	-04	04	-01	-04	-03	-04	-01	-03	02	01	00	-03	03	04	05	-02	03	00	-04	00	00	-02	01	-02	-04	-02	04	00	00	-05	-04	02	-02	-03	-01	00	01	01	-02	00
Logical Puzzles	23	50	51	28	28	32	34	23	40	27	32	35	26	39	35	34	32	27	26	28	30	54	48		-02	00	02	-04	-01	-02	-04	-01	-02	-01	-01	-04	00	01	06	00	-01	02	02	02	00	00	02	-01	-01	01	02	-01	00	01	00	00	-01	02	02	-02	-01	01	01	-01	01	-01	02
Map Planning	24	19	36	42	36	36	39	11	41	40	12	36	26	46	46	51	38	23	25	45	40	44	43	34		-02	-01	-01	00	03	-04	04	01	-03	-03	00	00	-01	00	-04	05	01	00	01	-01	-02	01	03	-03	02	-04	-04	03	00	-01	02	01	01	00	01	01	02	-02	-02	03	01	-01
Matrices VI	25	34	49	56	50	53	47	21	59	42	26	55	38	49	50	62	52	25	39	51	40	55	58	46	51		00	-03	01	-03	04	-01	-01	-01	00	02	01	01	04	-03	01	00	-03	-01	-02	02	01	-01	-01	02	01	00	-03	-01	00	01	02	-01	00	02	02	02	02	01	-02	-01	02
Mechanical Information	26	25	22	26	18	35	27	08	30	31	08	28	11	28	25	11	21	25	12	21	08	24	24	26	20	17		04	00	-02	04	00	-02	-03	00	-04	-02	-02	01	-01	-01	-03	06	03	01	-01	00	04	-03	03	-01	-03	01	00	-03	-04	-01	-04	02	00	-01	-02	-06	00	00	00	07
Mechanical Movements	27	20	32	26	30	29	22	08	33	25	13	35	22	37	30	21	28	18	30	31	20	24	19	19	26	26	40		00	-01	-01	-03	05	06	02	-04	03	-04	-02	03	01	-03	-04	04	03	00	02	-01	04	-04	-02	-03	-01	-04	03	03	-06	00	00	03	04	02	01	01	03	-01	-03
Mixed Series	28	40	48	44	39	40	51	37	57	39	36	56	48	48	52	63	39	39	32	49	40	67	60	49	49	62	23	29		01	06	03	-01	00	-01	02	00	00	00	02	01	04	-02	01	04	-04	-03	-05	02	-02	-02	-04	00	03	-01	03	01	00	02	02	-01	01	-01	-01	00	00	-01
Mutilated Pictures	29	29	12	39	37	20	13	10	24	36	09	29	18	13	15	41	21	11	21	20	46	28	30	21	31	37	07	09	35		-02	00	00	-02	03	-01	-05	04	01	04	03	-02	-01	-01	00	-02	01	00	-03	-01	04	03	02	02	05	-03	00	-02	03	06	-03	-03	-02	-02	-01	-02	-04
Mutilated Words	30	23	18	16	21	16	09	13	13	24	02	11	15	13	05	15	11	17	18	13	34	22	15	15	12	29	13	15	33	21		06	02	02	01	05	02	-01	01	-02	-03	00	01	-04	01	02	-03	01	-02	-01	-03	-01	05	-02	03	00	00	00	-03	-01	03	02	01	02	-01	-03	00
Nim	31	12	25	20	19	20	17	03	22	22	08	24	16	25	19	25	24	12	21	23	01	20	22	17	21	30	12	12	21	07	14		06	-03	-02	04	-02	00	-03	03	03	05	-06	00	01	-02	-05	-02	02	-03	01	-03	-03	-02	-02	-04	-01	03	-01	01	02	00	02	-05	04	01	06
Number Series	32	29	56	36	24	36	44	27	45	31	33	46	44	40	46	44	36	20	24	36	30	52	44	40	36	49	14	28	54	16	15	29		00	02	-02	00	00	-04	-05	-01	-04	02	-04	-02	03	-02	00	01	00	00	06	00	00	01	04	00	-06	00	-03	01	00	-01	01	01	00	00
Numerical Operations I	33	41	41	34	15	26	34	23	35	31	16	29	29	23	24	33	22	28	23	22	36	48	45	41	21	40	10	11	46	24	22	23	41		05	-06	00	-03	-02	-02	-05	00	00	02	04	04	00	-02	02	-02	-02	00	05	01	00	03	-02	01	-01	-02	01	01	-03	05	03	02	-01
Numerical Operations II	34	37	50	40	27	35	45	21	46	39	21	43	31	38	40	49	31	33	32	36	43	61	51	47	37	52	18	17	58	32	23	26	54	75		03	05	-01	01	00	00	-02	-02	-01	00	-01	02	03	-01	-02	02	00	00	-03	02	-01	-01	00	00	-02	02	04	-02	-02	-01	-01	-03
Numerical Puzzles	35	29	29	19	08	21	14	08	19	18	14	27	08	14	20	16	17	22	16	24	16	24	21	25	17	21	14	10	29	05	16	12	19	19	29		01	04	01	-05	02	00	-05	03	06	-02	-01	00	-03	-05	-02	-03	-02	01	-02	04	02	00	-02	02	03	04	-03	00	-01	-02	02
Overlapping Circles	36	23	28	41	33	34	37	11	46	26	18	39	33	41	36	42	29	13	29	41	27	39	35	25	34	49	11	25	36	17	15	22	34	24	38	11		-04	02	03	-03	-01	01	05	03	02	00	-01	01	-03	-02	00	-01	02	-01	-03	-03	00	02	01	03	03	-01	01	02	-01	02
Painted Blocks	37	44	52	34	18	26	33	17	33	28	21	33	30	34	32	33	19	32	41	28	28	45	41	43	24	37	25	25	41	19	18	22	40	35	42	30	19		01	00	-04	00	-04	-03	00	00	-01	03	-05	-01	01	-01	02	-02	02	02	03	-02	01	03	-01	00	00	00	-03	00	02
Paper Folding	38	24	44	45	42	47	39	18	41	47	25	52	37	47	43	47	41	18	31	49	29	46	37	39	37	56	33	36	48	31	21	19	41	27	42	20	40	35		01	05	01	-01	00	-07	00	00	00	02	00	06	-03	-01	06	-01	02	01	04	02	01	00	02	04	-01	-02	01	-05
Picture Analogies	39	31	39	33	30	31	29	25	40	26	24	45	39	37	39	36	27	23	23	40	17	48	41	31	18	41	03	20	42	23	13	27	37	36	40	09	37	29	39		09	-04	-05	02	-07	-05	02	02	-02	-01	00	00	-01	04	04	-02	00	-02	-02	08	-02	-01	02	-01	05	-02	-02
Picture Arrangement	40	44	34	37	27	29	28	27	38	30	21	32	22	21	21	44	31	12	31	36	39	52	47	40	35	51	05	10	50	41	23	17	36	32	41	18	29	24	39	41		04	-04	03	-04	-02	-02	03	00	00	04	-01	-02	-04	02	-02	01	-02	-01	09	-04	-04	01	-02	01	00	02
Picture Classification	41	34	25	27	29	20	25	08	21	22	03	19	24	21	14	21	19	13	19	27	37	22	37	36	25	33	08	11	29	22	15	18	18	22	22	14	19	34	22	16	35		06	01	-01	-02	00	-04	03	04	00	02	-01	04	-04	-03	02	02	02	-05	-01	-05	01	00	-02	02	-02
Picture-Group Naming	42	39	32	18	22	24	20	18	36	23	13	31	27	16	15	32	22	22	30	27	32	43	36	40	27	41	12	15	40	30	31	08	27	28	28	14	16	27	23	24	33	35		-01	04	02	02	02	03	03	-01	05	01	03	00	02	02	-02	-01	-03	-02	-01	-03	03	02	01	06
Planning a Circuit	43	16	24	37	25	40	29	09	32	38	12	30	27	28	35	27	33	10	22	36	28	35	29	22	30	30	38	36	36	22	13	13	23	19	25	18	32	24	45	20	25	17	11		-01	-04	03	01	01	00	-04	01	-04	05	00	01	02	-05	00	04	01	00	02	03	04	00	01
Practical Situations	44	36	28	13	24	20	21	23	41	30	19	35	26	32	32	31	22	21	14	22	15	37	30	38	28	33	23	28	42	12	20	14	26	22	24	23	30	21	18	12	21	12	26	16		-03	03	-01	-01	-01	-03	01	02	02	-04	00	-01	-03	01	-02	-01	00	-04	02	-02	01	00
Progressive Matrices B	45	17	36	34	31	28	35	27	43	33	26	48	32	32	38	40	32	18	23	29	18	47	34	33	27	49	18	22	40	22	09	14	43	26	28	08	38	22	38	25	31	13	20	22	32		03	06	-01	00	00	00	06	-01	-01	05	04	01	-01	-04	00	03	01	03	-01	03	-05
Progressive Matrices C	46	19	36	29	26	26	33	24	41	26	29	45	39	37	48	42	30	21	24	31	17	49	44	41	34	51	14	23	46	26	10	12	44	29	38	10	32	25	37	37	31	18	25	24	41	56		01	04	00	00	-02	00	01	-01	01	00	04	01	00	02	00	-01	01	-02	-02	02
Progressive Matrices D	47	12	35	33	30	28	37	21	43	21	31	46	36	38	52	47	29	18	26	33	21	47	41	31	36	49	13	22	43	21	10	13	44	14	31	07	36	26	38	36	35	13	21	23	32	57	58		-03	02	-02	00	03	01	00	01	02	-01	00	-02	-01	-01	00	01	-01	03	-01
Progressive Matrices E	48	21	42	49	39	42	39	12	42	32	32	49	34	40	44	54	43	25	37	39	38	56	45	36	37	60	17	34	55	31	16	25	45	35	43	13	39	29	50	32	39	26	35	32	26	45	53	47		02	00	02	-04	00	02	-03	-03	04	02	-02	04	01	02	-02	00	00	02
Reading	49	62	40	23	27	26	32	24	53	35	21	40	34	35	25	37	24	37	35	29	30	63	48	54	35	49	26	19	53	22	32	18	35	44	47	22	26	37	28	32	46	30	48	17	43	29	30	27	34		03	03	-01	01	-02	-02	-02	02	00	00	-01	-01	01	00	00	00	-02
Reading II	50	53	44	29	30	22	29	26	47	32	31	44	23	34	30	43	27	34	33	36	22	55	43	51	27	43	26	17	50	24	11	20	34	39	47	25	25	35	27	29	43	21	35	14	32	30	26	21	32	65		03	-01	00	03	-02	00	-01	02	-03	-01	-01	05	-01	01	01	-06
Reasons	51	20	18	19	10	01	20	16	16	02	04	09	12	05	14	17	05	35	19	13	21	23	18	21	18	20	-04	-01	19	15	05	02	17	23	25	15	10	21	-03	08	10	18	35	00	13	07	07	04	16	26	28		-04	02	02	-01	01	03	02	-01	00	01	03	01	-01	-02	-01
Sentence Order	52	60	37	26	29	22	32	25	45	23	21	35	30	29	19	35	31	24	29	27	35	55	40	52	35	39	12	09	49	26	27	12	30	47	45	25	27	33	19	28	46	29	42	06	37	28	19	21	21	66	61	26		-02	00	02	02	03	-02	-03	-02	00	02	02	00	03	-01
Series	53	32	39	29	30	40	45	23	46	34	37	58	43	37	47	39	46	29	26	39	21	52	43	39	33	47	23	24	55	21	10	17	45	34	38	22	41	25	53	45	29	15	25	36	38	45	46	45	42	39	40	13	32		-03	-01	-01	-02	-01	00	00	-01	-02	00	-04	-02	02
St.Gestalt Completion	54	21	10	08	21	16	13	15	30	25	05	17	18	08	07	26	23	07	18	17	35	30	21	19	24	31	-03	16	33	38	39	00	13	12	19	06	15	09	20	20	34	07	40	14	18	11	14	14	21	33	22	17	29	16		-01	00	03	01	00	00	00	02	-01	00	01	01
Suffixes	55	23	21	17	22	17	06	21	22	20	09	28	22	16	17	15	19	46	14	26	14	34	24	27	19	29	08	18	40	09	24	08	22	36	29	26	03	23	17	23	12	05	41	10	20	16	19	08	16	36	28	28	30	23	23		02	00	07	00	01	-02	-01	02	00	05	02
Surface Development	56	17	34	52	41	57	36	13	43	47	09	42	31	42	38	51	48	15	23	40	33	38	35	23	42	55	30	27	46	37	20	21	36	24	35	15	32	30	54	27	33	23	25	48	17	40	35	35	44	17	19	03	13	35	22	17		02	-04	01	-03	-04	02	-01	-02	02	02
Things Round	57	30	25	08	15	04	26	17	27	16	08	17	15	13	14	17	06	26	13	17	22	30	22	32	29	22	-01	08	26	16	12	13	11	33	35	18	14	19	14	16	11	19	33	-02	14	05	12	-01	15	34	28	49	39	17	29	29	09		02	00	02	02	02	00	-02	02	-02
Topics	58	25	20	19	02	07	13	22	11	03	07	02	15	00	06	12	14	30	24	13	12	20	22	28	18	23	-01	-01	18	18	06	08	15	25	22	16	16	26	04	10	15	24	30	01	17	14	19	08	17	19	20	56	24	12	17	32	02	47		03	-01	00	-02	-02	01	-02	02
Verbal Analogies	59	48	56	29	35	35	43	29	56	29	43	60	40	38	53	54	34	34	30	40	22	62	52	56	39	59	23	34	64	27	13	24	51	40	48	28	35	42	45	54	50	18	40	26	41	43	51	47	47	57	54	17	49	57	22	34	30	29	19		00	-01	04	03	00	-01	03
Verbal Class. I	60	53	49	40	42	33	44	32	55	42	23	52	46	47	46	50	32	28	31	43	43	68	54	49	41	55	24	28	65	32	25	21	47	43	52	26	38	42	39	40	47	35	41	32	31	39	40	37	44	58	59	24	56	43	26	31	35	28	17	58		08	01	03	01	-04	00
Verbal Class. II	61	46	50	41	44	37	40	35	56	45	30	62	45	50	53	51	34	31	33	44	39	64	55	49	43	54	27	30	68	32	21	17	45	40	51	27	39	39	44	41	42	25	42	34	35	46	41	39	43	56	60	26	55	49	28	32	37	31	19	61	87		01	01	01	-02	-01
Vocabulary	62	58	53	27	33	27	29	34	53	35	28	45	31	37	37	37	24	45	37	34	33	67	49	57	29	51	20	31	58	23	37	24	39	44	46	26	30	46	38	41	47	31	47	24	42	36	38	32	41	74	65	29	59	42	37	42	25	33	23	65	63	62		-01	00	00	00
Word-Group Naming	63	53	46	32	34	33	40	27	47	34	22	45	35	38	37	44	31	38	39	38	38	63	54	52	35	55	14	23	57	26	28	18	43	55	52	30	29	47	31	40	40	33	58	20	31	30	33	29	41	59	53	41	59	37	27	49	25	41	34	62	63	59	63		00	02	-01
Word Selection	64	51	51	32	37	42	37	33	47	33	44	51	34	39	40	35	36	34	22	38	25	56	47	58	37	49	26	33	52	21	18	24	46	42	41	28	33	37	42	48	41	30	42	30	39	38	42	38	41	52	49	14	49	47	20	34	28	24	23	65	53	56	59	53		-02	-03
Word Squares	65	43	48	46	50	40	46	36	56	38	37	55	43	44	52	51	36	26	42	46	50	64	51	47	43	55	21	28	59	32	12	22	46	42	50	23	40	41	48	44	44	35	44	31	27	40	33	41	48	48	55	26	55	47	24	34	39	37	19	61	61	65	52	63	53		02
Education	66	35	35	20	24	12	30	27	44	24	19	39	33	30	34	34	14	29	28	24	29	53	41	36	25	44	14	14	44	16	20	30	37	45	45	17	31	32	21	38	29	12	43	11	26	22	35	26	36	44	34	27	36	38	27	37	22	34	27	52	43	44	50	49	32	46	

TABLE 12

Centroid Factor Loadings for the Major Study

Test	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	h^2
1	56	-40	-12	27	-07	-12	08	-12	08	-07	15	-06	-07	-04	-07	-04	66
2	65	03	-14	-07	-17	-07	-07	-12	20	-08	-06	05	-11	11	11	-08	60
3	58	26	31	05	-09	-10	09	-07	-03	13	02	-12	06	03	-17	12	62
4	54	18	14	18	11	-03	06	16	-15	03	05	-14	-05	-15	10	16	52
5	56	37	18	19	-22	10	04	-06	09	-20	-12	-06	10	13	-07	08	69
6	58	18	04	-14	-06	-15	05	02	-07	03	04	14	02	09	13	-13	48
7	37	-13	-19	-10	07	12	06	-07	-16	03	-14	02	-05	04	-08	-05	28
8	71	09	-08	02	13	-11	-02	17	-02	-02	05	16	-09	-04	08	-09	63
9	54	16	13	24	-06	04	-10	-06	-15	-07	02	12	-06	-09	-06	05	47
10	38	06	-20	-15	08	11	17	-17	-03	-18	16	-17	07	17	09	-10	42
11	70	20	-19	-03	12	17	-02	04	-11	-08	11	-11	-06	08	02	16	66
12	55	16	-12	-12	04	-02	-06	-06	-12	-06	-18	-07	-13	02	-07	-16	47
13	60	31	-10	09	-11	-25	-03	20	-10	13	-10	-11	14	-13	-02	-02	68
14	62	31	-20	-10	-05	-09	09	09	-21	14	-06	-07	10	-09	07	-05	65
15	67	16	17	-12	20	-10	-02	06	04	11	-05	14	12	14	06	05	65
16	53	33	18	14	-10	11	11	03	16	-19	-17	10	11	11	-13	08	62
17	44	-20	-15	-13	-24	23	-07	12	-12	14	05	-11	14	-04	-11	07	48
18	48	-03	10	-11	06	-07	-17	10	19	16	13	-18	-08	19	-10	-10	47
19	60	24	11	05	-07	-05	05	12	-05	-07	-10	-15	05	05	-06	-05	50
20	52	-10	39	14	12	-12	03	-14	-22	19	08	-16	12	-07	12	-09	66
21	80	-10	-12	-08	14	-06	-08	-06	-10	05	09	-02	08	06	-05	-05	75
22	69	-01	03	-06	02	-16	-02	-04	07	07	-07	14	-03	-03	10	09	56
23	65	-19	-13	08	-12	-02	14	-10	16	-03	05	06	04	-07	17	01	59
24	58	14	20	06	-06	-04	12	18	-03	10	-08	14	13	-06	16	-10	54
25	78	16	20	-05	11	-01	03	06	18	-03	-08	01	07	-09	02	10	75
26	33	16	-14	33	-28	09	-13	05	-05	13	26	13	-06	13	02	08	50
27	40	23	-10	20	-13	13	-20	18	03	11	12	-12	-10	04	13	-09	45
28	80	-02	-05	-03	09	03	-06	-06	-12	06	-13	08	21	12	05	-04	77
29	42	-04	37	12	25	10	03	-16	-11	08	06	07	-10	-07	07	14	49
30	32	-18	16	19	08	16	-28	-07	05	04	-07	-08	06	-14	-05	-14	37
31	32	11	04	-08	-11	-14	-15	09	17	-10	03	05	-07	-11	-12	10	26
32	63	15	-12	-21	-07	-10	-04	-18	07	-04	-11	07	03	05	07	-12	58
33	57	-26	09	-24	-18	-14	-15	-24	-05	-16	13	17	10	-13	-09	14	72

Decimal points have beem omitted.

TABLE 12

Centroid Factor Loadings for the Major Study (Continued)

Test	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	h^2
34	69	-12	12	-22	-16	-19	-13	-18	-09	-10	11	19	19	-08	02	02	77
35	34	-13	-03	05	-25	06	04	-04	03	-06	04	-04	09	11	-02	-06	23
36	52	25	08	-05	12	-14	07	09	04	-02	12	-02	-06	-12	-19	-14	48
37	55	-11	-05	-04	-28	-13	-14	-13	13	17	06	-11	-14	08	04	-06	55
38	62	35	08	08	-04	07	-11	-12	-05	-10	08	-06	-05	04	07	-06	60
39	55	07	-08	-17	07	-08	-07	-08	-04	-24	-10	-16	-12	-12	-08	03	50
40	58	-12	16	11	26	-08	08	-27	14	-06	-05	05	02	04	-06	-03	58
41	40	-11	15	14	-08	-17	13	-13	15	13	-06	-13	-18	-08	08	03	39
42	53	-33	13	03	09	17	-08	09	13	-05	-20	-11	-12	02	16	08	58
43	44	29	10	21	-12	09	-10	-13	-14	08	08	02	-07	12	-06	-09	44
44	47	-02	-26	13	05	16	07	10	16	06	17	14	09	-16	-03	-15	45
45	54	26	-17	-11	19	13	14	-08	10	12	06	12	-02	-02	-10	08	54
46	57	20	-19	-19	16	16	07	-14	10	17	-03	09	04	-20	05	08	62
47	54	31	-18	-18	27	04	11	-07	11	19	-06	-02	07	-08	07	-04	61
48	65	23	12	-15	11	08	-04	-04	14	12	10	-08	09	05	08	11	61
49	68	-37	-16	19	10	-08	-10	10	12	-07	07	08	12	-05	-07	-03	74
50	63	-26	-17	11	04	-13	06	13	03	-11	14	12	06	19	-07	11	65
51	31	-39	17	-27	-18	10	22	26	-06	17	-05	02	-06	06	-06	-05	55
52	61	-42	-05	16	09	-19	19	08	06	-16	05	04	11	05	-08	-05	73
53	64	20	-20	-08	05	16	07	-02	-08	-18	10	04	03	03	-08	-06	59
54	36	-21	24	16	32	27	-14	09	-04	-08	-14	06	-02	-08	07	-22	55
55	42	-29	-06	-05	-16	29	-16	15	-12	-11	-17	-12	12	-06	-07	17	55
56	56	39	27	12	-05	11	-12	-09	-06	06	-07	11	-06	03	-03	09	63
57	38	-38	16	-16	-17	06	12	26	-15	-10	03	11	-14	-12	12	-14	57
58	31	-36	19	-30	-23	24	31	08	14	14	-05	04	-22	-08	-17	-10	71
59	76	-04	-31	-10	08	02	05	04	09	-16	03	02	03	05	19	06	77
60	77	-14	-10	13	10	-22	04	-03	-15	09	-15	06	-10	13	-07	09	80
61	78	-09	-16	12	12	-08	07	04	-24	06	-12	07	-13	14	-05	12	82
62	74	-34	-21	13	06	04	-13	02	12	02	04	-04	03	-06	-08	-03	78
63	73	-34	02	-09	-06	-04	-03	10	06	-03	-07	-13	03	07	04	12	72
64	70	-05	-24	10	-08	08	14	-10	09	-16	02	-10	-04	-08	10	06	67
65	77	-04	02	-05	07	-14	12	06	-15	-08	07	-16	-11	14	11	04	74
66	56	-20	-06	-27	09	-03	-20	15	-05	-09	02	06	-07	-13	-03	02	55

Decimal points have been omitted.

TABLE 13

Distribution of Sixteenth-Factor Residuals for the Major Study

Value of Residual	Frequency
+090 +099	1
+080 +089	4
+070 +079	1
+060 +069	21
+050 +059	41
+040 +049	66
+030 +039	115
+020 +029	228
+010 +019	269
+000 +009	330
-010 -001	327
-020 -011	312
-030 -021	213
-040 -031	126
-050 -041	60
-060 -051	21
-070 -061	8
-080 -071	2
Total	2145

Decimal points have been omitted.

TABLE 14

Oblique Factor Matrix for the Major Study

Test	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'	K'	L'	M'	N'	O'	P'
1	13	04	40	07	25	-03	10	09	04	12	02	02	02	11	08	21
2	09	17	02	-05	11	-01	05	07	28	33	-08	17	29	-09	03	13
3	01	03	06	37	16	19	04	03	-00	12	04	30	-03	07	02	03
4	22	-01	04	26	-09	37	22	08	-19	-08	11	-01	18	26	03	12
5	01	00	-01	04	04	08	04	05	04	09	08	55	04	02	01	03
6	09	14	-01	06	-01	26	02	20	20	31	-12	07	13	00	17	08
7	26	17	07	-06	01	-07	02	06	16	-02	06	03	-04	04	09	-05
8	25	14	20	08	-18	26	23	08	09	15	-10	-03	23	12	23	25
9	22	-07	06	-02	-08	08	22	-05	-06	16	-02	14	-03	20	06	24
10	10	30	03	08	09	02	-02	45	20	01	06	12	04	00	00	-05
11	34	18	05	19	-17	12	17	18	03	-05	10	01	18	01	-03	16
12	29	10	-01	04	-01	07	24	05	33	10	-03	15	07	02	07	00
13	04	06	13	22	37	50	14	-01	11	12	15	07	08	-01	00	08
14	13	26	00	13	01	44	09	16	14	11	12	02	05	01	05	02
15	09	18	10	22	-12	19	-07	15	07	20	-02	10	23	10	07	03
16	01	07	09	04	-07	05	03	-02	-03	05	02	56	03	01	12	01
17	-02	16	05	12	04	08	-06	07	05	00	43	01	01	03	09	14
18	-02	06	18	43	08	04	05	09	29	05	03	04	26	05	09	23
19	09	00	07	21	01	28	14	11	14	03	09	30	09	07	10	01
20	03	00	10	31	26	31	-00	31	04	21	13	-02	05	48	-01	01
21	21	22	25	21	01	10	06	24	20	19	11	-03	10	13	04	14
22	15	16	07	07	00	13	04	01	03	30	-05	02	26	04	03	07
23	01	28	18	-05	18	11	-03	17	-00	25	07	08	21	09	07	11
24	-04	13	07	06	00	42	-00	14	02	20	04	16	16	23	25	07
25	04	23	12	24	-08	24	14	07	-05	15	09	26	29	19	09	04
26	06	-03	08	-05	01	03	-04	-05	-02	08	-01	-03	00	-03	03	50
27	03	03	02	10	00	21	13	05	16	-01	12	00	25	14	05	41
28	17	22	15	04	00	14	-10	24	20	23	18	12	12	17	01	01
29	22	04	01	13	-01	01	09	08	-19	07	-04	00	09	42	03	08
30	-04	00	17	05	08	-02	13	00	10	10	23	08	09	43	-01	18
31	01	-03	04	12	-14	05	23	-18	-03	17	-04	09	14	-13	04	15
32	08	27	-02	-03	07	10	03	14	31	38	-05	17	16	-07	00	-02
33	06	04	02	02	-03	-08	08	05	-05	52	07	01	00	-05	-02	05

TABLE 14

Oblique Factor Matrix for the Major Study (Continued)

Test	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'	K'	L'	M'	N'	O'	P'
34	02	09	02	04	-01	11	03	18	06	58	06	03	05	02	02	05
35	-06	04	09	-01	17	00	-09	14	12	13	13	19	00	-01	08	07
36	08	15	23	31	-06	25	34	03	11	06	-12	15	00	08	25	18
37	00	07	02	15	30	01	-00	02	29	32	02	02	23	-05	-02	22
38	15	08	-06	09	-01	14	19	18	16	19	-01	21	13	17	00	21
39	29	06	-02	12	-09	05	35	04	12	09	04	11	14	-02	-04	-06
40	13	17	29	11	14	-09	04	13	06	18	-09	20	06	24	01	-03
41	04	03	07	15	33	09	06	-04	02	14	-08	08	19	12	00	02
42	17	01	03	06	-01	-02	05	06	-00	-02	20	08	44	28	05	01
43	13	-02	00	04	09	04	07	05	18	13	-05	18	-07	15	04	28
44	-05	39	36	-05	-01	14	09	04	04	02	11	08	04	18	24	30
45	14	47	15	11	-07	02	07	03	01	00	-05	12	03	02	10	14
46	07	57	03	04	-02	10	06	05	-00	13	09	04	14	12	01	07
47	05	54	09	17	01	21	04	15	14	05	04	06	17	11	00	00
48	-02	32	00	32	-01	16	-01	20	04	13	13	12	28	15	-03	11
49	09	11	51	08	-04	06	09	07	02	12	16	-02	14	16	10	25
50	21	04	39	10	-09	01	-04	13	-02	05	01	00	09	-09	12	17
51	00	05	03	15	08	11	-09	06	06	-02	11	07	09	04	43	-04
52	12	05	50	11	07	10	02	19	-00	06	04	09	04	08	20	03
53	22	29	12	03	-14	08	18	22	12	04	05	19	-01	03	16	15
54	15	01	17	-04	-14	03	18	12	06	-04	12	08	18	58	22	12
55	11	-03	-01	-02	-12	-01	03	01	-06	-07	48	10	12	10	00	-01
56	15	01	-10	06	-06	07	11	-07	-00	18	-05	27	07	18	02	18
57	12	-06	-02	-04	-07	21	16	12	-01	12	04	-03	17	17	46	08
58	-06	22	03	09	20	-07	05	-07	06	00	01	25	05	07	52	02
59	21	32	13	01	-11	13	05	26	07	12	10	02	33	-02	04	08
60	43	01	25	10	05	05	03	-01	11	10	-07	00	08	01	02	04
61	52	03	20	06	-06	06	06	02	07	-01	-03	-02	07	03	08	08
62	12	20	41	11	06	01	11	06	11	09	22	-01	18	19	06	27
63	13	05	13	21	05	09	-01	14	06	11	24	06	33	05	04	00
64	17	27	13	-02	11	09	13	17	01	07	13	16	18	07	02	10
65	34	03	07	27	01	23	12	30	11	05	00	02	24	06	09	02
66	22	07	07	12	-26	08	26	02	06	16	10	-13	24	05	14	13

TABLE 16

Reference Vector Cosines for the Major Study

	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'	K'	L'	M'	N'	O'	P'
A																
B	-35															
C	-17	18														
D	-18	01	24													
E	-37	21	08	12												
F	-26	06	01	27	01											
G	-36	19	-04	-11	33	-13										
H	-19	25	-04	15	18	31	30									
I	05	-04	-04	-01	-38	08	-02	-21								
J	-28	04	-21	-30	18	03	12	07	-21							
K	-50	13	-04	23	08	14	47	27	13	-06						
L	-26	08	10	-08	23	-16	05	-03	-18	-08	12					
M	-02	00	-32	10	-15	17	-01	08	01	05	-01	-23				
N	-10	15	11	04	11	25	-18	29	05	-05	-01	-05	10			
O	-01	12	27	-03	-15	19	-29	-02	-10	-15	-37	23	-15	16		
P	-04	01	29	07	-16	-05	-30	-19	-01	04	-12	-26	06	19	32	

Decimal points have been omitted.

1D19129

COLLEGE LIBRARY

Date Due

Due	Returned	Due	Returned

Factor analysis of reasoning t main
153 68A236f C 2
3 1262 03224 8287

153.68
A236f
c.2